Driver Responses to Unintended Acceleration Events on a Closed Driving Course

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Table of Contents

List of Tables and Figures 4
Introduction 6
  Overview of Findings 6
  Constraints 6
  A complete description of the research vehicle is given in 7
  External Project Oversight 7
  Participant Demographics 7
Procedure 8
  Video Coding 11
Results 13
  UA Event 13
  Deceleration Events 32
  Exit Questionnaire 44
Appendix A: IRB approved procedure document 49
Appendix B: Screening Requirements 53
Appendix C: Pre-Study Participant Information Packets 56
Appendix D: Post-Study Participant Information Packet 62
Appendix E: Facilitator Instructions V.3 64
Appendix F: Run Sheet 65
Appendix G: Study Advertisements and Recruitment 68
Appendix H: El Toro Track Diagrams 78
Appendix I: Site and Vehicle Photographs 80
Appendix J: Exit Questionnaire Responses and Comments 100
Appendix K: A Vehicle Description Report Prepared by Steve Loudon 106
1 Introduction 108
2 Data Acquisition System 108
  2.1 Vector CANtech GL3000 109
    2.1.1 ECM Input Signals 109

- 2.1.2 External Sensors 109
- 2.1.3 Vehicle CAN Messages 110
- 2.1.4 GL3000 Output 110
- 2.2 Racelogic Video VBOX Pro 110
- 2.3 UA Event Simulator 110
- 3 Vehicle Preparation 111
- 3.1 Data Acquisition Installation 111
- 3.2 Vehicle External Sensor Installation 113
- 3.3 Passenger Brake Redundant Brake 117
- 4 Pre-test Vehicle Checkout 118
- 5 Daily Vehicle Checkout 118
- 6 Appendix – Data collected 118

List of Tables and Figures

Tables

Table 1 8
Table 2. UA event variable names and descriptions 13
Table 3. UA event response means for males and females 14
Table 4 34
Table 5 39
Table 6 40
Table 7 41
Table 8 42
Table 9 43
Table 10 44
Table 11 45
Table 12 47
Table F13 65

Figures

Figure 1. Histogram of participant ages 8
Figure 2. Test Track Layout and Measurements 9
Figure 3. Schematic representation of UA coding events. RT Event Registry = time it took for the participant to “register” that a UA event occurred in milliseconds. RT Brake = time it took for participant to touch the brake after the UA event in milliseconds. Speed at cone hit = speed at which the participant hit the cones in mph. Max velocity = maximum velocity after UA event in mph. Seconds to stop = time it took for the participant to come to a complete stop after the UA event in seconds. Max pedal force = the maximum amount of force applied on the brake pedal. 11
Figure 4. Correlations between behavioral variables in the UA event 15
Figure 5. Correlations between behavioral variables in the UA event 16
Figure 6. Breakdown of frequency of cone wall strikes. 17
Figure 7. Frequency and types of secondary behaviors that were observed after braking 17
Figure 8. Frequency of UA events where participants braking was characterized as “pumping” 18
Figure 9. Reference braking plot from UA event where participant did not pump their brakes and stopped prior to hitting the cone wall (Participant 53). 20
Figure 10. Time series of braking behavior and forces during a brake pump (Participant 22 - 2). 21
Figure 11. Time series of braking behavior and forces during a brake pump (Participant 25 - 3). 22
Figure 12. Time series of braking behavior and forces during a brake pump (Participant 34 - 2). 23
Figure 13. Time series of braking behavior and forces during a brake pump (Participant 40 - 2). 24
Figure 14. Time series of braking behavior and forces during a brake pump (Participant 46 - 3). 25
Figure 15. Time series of braking behavior and forces during a brake pump (Participant 50 - 3). 26
Figure 16. Time series of braking behavior and forces during a brake pump (Participant 52 - 2). 27
Figure 17. Time series of braking behavior and forces during a brake pump (Participant 54 - 3). 28
Figure 18. Time series of braking behavior and forces during a brake pump (Participant 56 - 2). 29

Figure 19. Time series of braking behavior and forces during a brake pump (Participant 63 - 3). 30
Figure 20. Time series of braking behavior and forces during a brake pump (Participant 68 - 2). 31
Figure 21. Brake pedal release duration after during UA event 32
Figure 22. Deceleration Event variable names and descriptions 32
Figure 23. Deceleration event schematic definition 33
Figure 24. Throttle Open, Pump. 35
Figure 25. Throttle Open, No Pump. 36
Figure 26. Throttle Closed, Pump. 37
Figure 27. Throttle Closed, No Pump. 38
Figure 28. Observed frequencies of ability to stop the accelerating vehicle after the vacuum is depleted 39
Figure 29. Mean deceleration rate of men compared to women across conditions 41
Figure 30. Mean brake pedal force of men compared to women across conditions 42
Figure 31. Mean vacuum pressure of men compared to women across conditions 43
Figure 32. Mean main cylinder pressure of men compared to women across conditions 44
Figure 33. Distribution of responses of how surprised participants were about initial UA event. 46
Figure 34. Distribution of responses of how anxious participants were during initial UA event. 46
Figure 35. Distribution of responses to how familiar participants were with the issue of UA. 47
Figure H36. Aerial view of the El Toro Airfield track 78
Figure H37. Schematic of the track layout and the course driven by the participants. 79
Figure I38. View of the overhead camera 80
Figure I39. View of camera on dashboard looking out the windshield 81
Figure I40. View of camera on passenger side door 82
Figure I41. 2005 Toyota Camry driven by participants 83
Figure I42. Facilitator's accelerator button and throttle controls 84
Figure I43. Instrumentation device in trunk of vehicle 85
Figure I44. Instrumentation device underneath the front passenger seat 86
Figure I45. Driver-side break and accelerator, sensors, and pedal camera 87
Figure I46. Passenger-side reduntant brake pedal 88
Figure I47. Intake tent 89
Figure I48. Sign out tent 90
Figure I49. Complete set up, with the intake tent on the right and sign out tent and track on the left 91
Figure I50. View looking eastward down the track 92
Figure I51. First set of cones encountered during the training 93
Figure I52. Second set of cones encountered during training 94
Figure I53. Cone wall used in the initial UA event 95
Figure I54. Cone wall used for the initial UA event looking eastward down the track 96
Figure I55. Third set of cones encountered during part A of training 97
Figure I56. Beginning of the slalom section (part B) of the training 98
Figure I57. End of the slalom course (part B) and end of the track; turn-around point and beginning of UA event (part C) 99

Introduction

This document provides the results of a research experiment that was completed on May 19th, 20th, and 21st of 2013 at the California Great Park in Orange County California. This was a driving research study using an instrumented research vehicle. The purpose of this study was to document the variety of responses that people exhibit to Unintended Acceleration (UA) events. Participants were completely unaware that a UA event would occur during this testing and were told that the purpose of the research was to evaluate how older and younger drivers differ in their ability to safely control a vehicle. This ruse was very successful in getting participants to respond in a natural manner. Following the UA event, participants completed a set of four deceleration events where their ability to stop the vehicle under various conditions was recorded.

Overview of Findings

- Unintended Acceleration (UA) Event
    - More than half of participants reported being "Extremely" surprised by the UA event (95% reported being at least "Somewhat" surprised by the event)
    - 40% of participants were unable to bring their car to a stop before hitting the cone obstacle.
    - 18% of participants exhibited some form of brake "pumping" during the UA event; 8% of participants exhibited a "clear" brake pump.
    - Secondary responses to the event included: Putting the car in park, putting the car in neutral, turning off the car, turning out of the way of the cones, and other behaviors.
- Deceleration Events
    - Women were much less able than men to bring the car to a stop in the Throttle-Open, Brake-Pump condition.
    - Height, Weight, and Gender were all related to the ability to bring the car to a rapid stop; age was not. (In the interest of safety, all participants in this research were required to meet strict health screenings before participation.)
    - In the interest of safety, all participants in this research were required to meet strict health screenings before participation.
    - Brake pedal force was significantly associated with stopping distance in all conditions

Constraints

In order to ensure the safety of our participants, a number of constraints were placed on the design of this study. First, this research was carried out on a closed driving course with a wide, paved driving surface. Second, vehicle speeds in this research were generally less than 40mph and never exceeded 50mph for any single subject. Finally, in order to reliably elicit the UA event, and to ensure the safety of our participants, it was necessary to have a researcher in the vehicle at all times. Because of these constraints, the variety of behavioral responses that were observed in this research is likely an underestimate of the types and variety of behavioral responses that might be expected in an actual UA event.

One additional constraint of this research was that all research participants had to be healthy at the time of participation. The screening requirements for participation are found in Appendix B. These strict screening requirements were critical to ensure that no health incidences arose during the UA event. However, in the real world, no such selection would be expected. Thus, the data obtained in this report are likely an underestimate of the types and variety of responses that might be expected if an older and less healthy population were evaluated.

Research Vehicle: A 2005 Toyota Camry was used as the research vehicle. The vehicle was instrumented by Loudon-Engineering.com and contained a four camera data collection system that was purchased from RaceLogic.co.uk. In addition, instrumentation included:

Name	Description	Unit
Analog Inputs		
VPA	First accelerator pedal sensor, measured at the accelerator	Volts
VTA	First throttle sensor, measured at the engine	Volts
STP	Secondary brake switch signal (Binary)	Volts
Brake Pedal Force	Pounds of pressure on the brake pedal	Pounds
Vacuum Boost	Vacuum pressure in braking system	PSI
Main Cylinder pressure	Pressure in the main braking cylinder, directly related to the vehicle braking force.	PSI
CAN Data		
Engine Speed	Engine speed	RPM
GPS Data		
Velocity	The speed of the vehicle	KPH

A complete description of the research vehicle is given in

External Project Oversight

The general procedures used in this research were reviewed and approved by the Western IRB (WIRB.com). The principle role of IRBs is to protect human subjects from physical or psychological harm (WIRB, 2013). Documents that were approved by the IRB are appended to this manuscript (see Appendix A - Appendix G).

Participant Demographics

Eighty-two participants (39 male and 43 female) from Orange County, CA participated in the experiment. Participants ranged in age from 35 to 75 years of age ($\bar{x}$ = 58.1 years, SD = 9.6). Participants reported years of driving experience ranged from 19 to 60 years ($\bar{x}$ = 40.9 years, SD = 9.7). Descriptive statistics for the resulting data are presented in Table 1. Figure 1 reports age frequencies and distributions. Other demographic variables that were collected for each participant include height (inches) and weight (pounds).

Table 1

Participant Ages and Driving Experience

	Mean	SD	Minimum	Maximum	Range
Age	58.06	9.58	35	75	40
Years Driving Experience	40.90	9.71	19	60	41

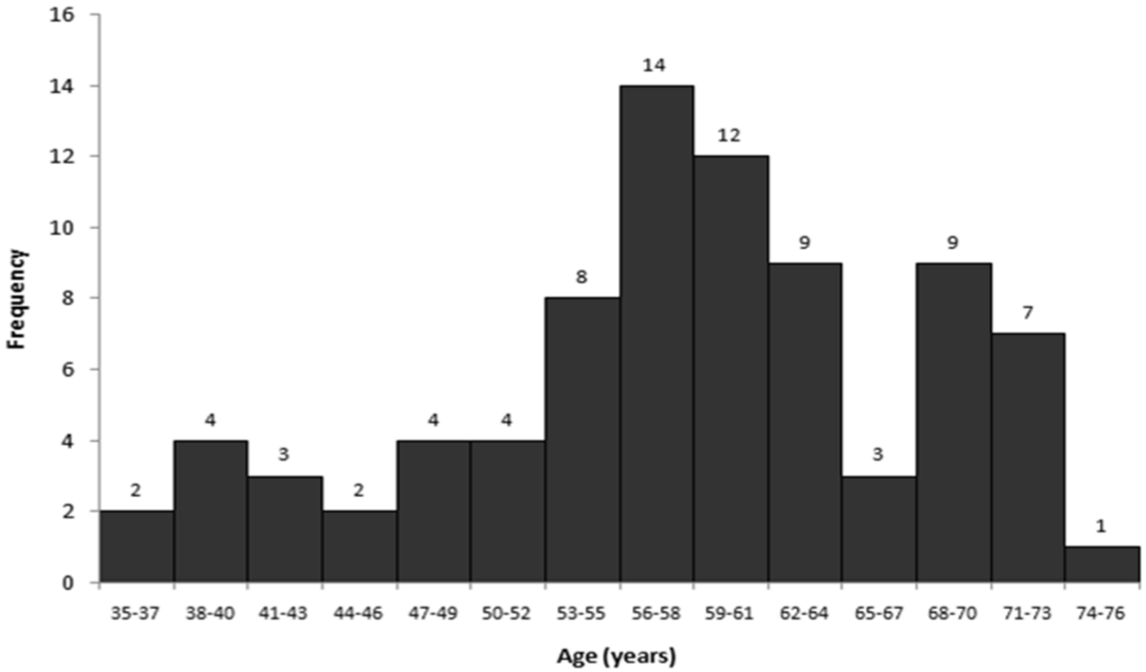


Figure 1. Histogram of participant ages

Procedure

The following section describes the general experimental procedures that were followed during testing. As with all human subjects testing, there was some variability in the exact instructions that participants were given during testing. Furthermore, unanticipated constraints to the test track that necessitated some general procedural modifications to ensure that the data remained robust. Additionally, for research investigations that use human subjects, some instruction variability is unavoidable due to differences in understanding and clarity of communication between the researcher and the participant. In all cases, participants were made to feel comfortable with the procedure and the experimenter.

It is also important to note that some procedural modifications were made to the UA event for the first 20 participants. However, the deceleration events remained consistent for all 82 participants. Changes were required because many participants immediately asked the experimenter for additional instruction once the event occurred. After 20 participants it was determined that a clear behavioral goal was need to ensure that all participants had an adequate understanding of what was expected of them. The following is a description of the experimental procedures that were followed during testing. The unique characteristics of the UA event are for the first 20 subjects are described in section C "UA Event". Lettering used in this outline corresponds to the lettering that is superimposed over the test track layout shown in the topmost image of Figure 2. For an aerial view and photographs of the track, see Appendix H and Appendix I, respectively.

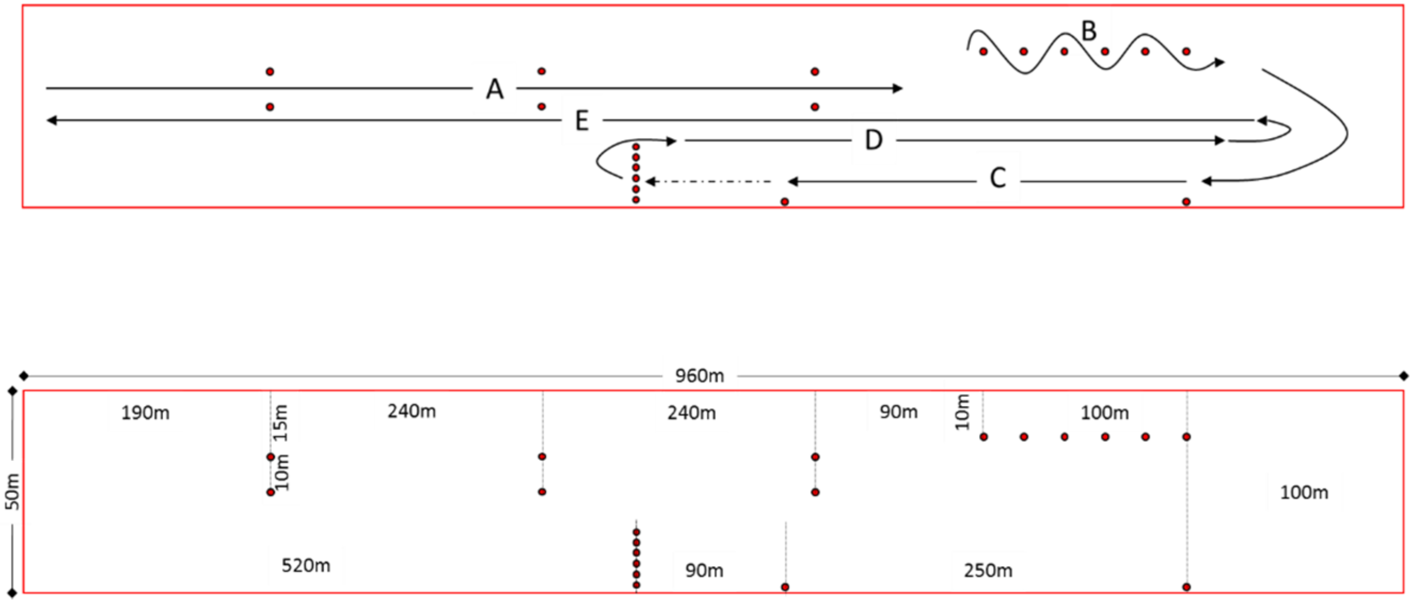


Figure 2. Test Track Layout and Measurements

A. Practice: Braking and Acceleration. Participants were instructed to accelerate up to 35mph and then to apply their brakes and come to a stop as soon as they passed through the first set of cones. After their vehicle came to a complete stop, participants were instructed to accelerate up to 35 mph again and to apply their brakes until they again came to a complete stop. For this second braking event, participants were instructed to brake harder than during the first. After coming to a complete stop, participants were again instructed to accelerate to 35mph and to brake as soon as they passed through the final set of cones. This time, however, participants were instructed to apply their brakes as hard as they were able. If participants did not apply their brakes at full force, they were instructed to repeat the final braking event a second time.
B. Practice: Lateral Control. After the braking practice, participants were instructed to weave through 6 cones that were spaced 20 meters apart. Participants were instructed to proceed at a comfortable pace around 10mph. The purpose of this exercise was to familiarize participants with the lateral control of the vehicle.
C. UA Event: Following the practice events, participants lined their car up on the eastern tip of the runway facing west. Once the vehicle was appropriately positioned and stopped, participants

were oriented to the wall of cones that was placed in front of their vehicle 340m down the track. After the wall was identified, participants were instructed that their next task was to accelerate their vehicle to 20mph and to maintain that speed until just before the cone wall where they were to bring their car to a stop, maintaining 2-3 car lengths from the cone wall. If participants were unable to maintain 20 mph, they were instructed to either slow their vehicle, or to speed up.

The speed of 20mph was chosen because it ensured that vehicle speeds would remain within a safe range without impeding the ability to address the primary research questions. Slower speeds would have been safer but may *not* have elicited a natural response. Faster speeds would have elicited a natural response but would not have been as safe.

The UA event was triggered 90 meters from the cone wall. During the UA event, the experimenter did not say anything unless the participant asked for instruction. If the participant asked for instruction, the experimenter said “Brake”. Once the car came to a complete stop, participants were informed that what they just experienced was part of the study.

The distance of 90 meters was chosen because at 20-40 mph it gave the participant 5-10 seconds to bring the car under control. If participants failed to bring the car under control, they would eventually run over the cone wall. In pilot testing it was determined that by having a clear goal in place (i.e., come to a stop 2-3 car lengths before the cone wall), participants typically required no additional instruction after the onset of the UA event.

For the first 20 subjects of this research a cone wall was not in place and participants were instructed to either a) accelerate to 35 mph and then gradually slow to 15mph (this was the deceleration condition), or b) accelerate to 20-25 mph and then maintain that speed (this was the acceleration condition). In the deceleration condition, the UA event occurred as participants slowed below 20mph; in the acceleration condition, the UA event occurred just before participants reached 20mph.

D. Deceleration Events: Four deceleration events followed the UA event. These are shown in the table below. For simplicity, these are labeled Events 1-4 in the table. However, they are sometimes referred to by other names in this report.

	Throttle: Closed	Throttle: Open
Brakes: No Pump	Event 1	Event 2
Brakes: Pump	Event 3	Event 4

For each of these events, participants were instructed to accelerate their vehicle to 30mph. They were told that the experimenter in the vehicle would say either “Stop” or “Pump” once the vehicle reached 30mph. If the experimenter said “Stop” they were instructed to immediately stop their vehicle as quickly as they were able. If the experimenter said “Pump” they were told to pump their brakes 4 times and then stop their vehicle as quickly as they were able. The exact instructions given to participants often varied depending on how well the instructions were understood and followed. If the instructions were not followed, clarification was offered and the braking event was repeated. Events 1-3 were counterbalanced across participants, while event 4 was always given as the last event.

E. Return to Intake: After all braking events were completed, participants were instructed to return their vehicle to the west end of the runway where they exited the vehicle and filled out a brief exit questionnaire. Following this, they were thanked for their participation and paid $50.

Video Coding

Participants' behaviors were recorded on video and coded. Video coding was carried out by 2 trained research assistants. In order to ensure consistent coding, the first five videos were coded by both research assistants. Results of these independent codings were compared and any discrepancies were discussed and resolved. Following this brief training, the remaining videos were roughly evenly divided between coders and coded independently.

During coding, timestamps were recorded for four discrete events: the start of the unintended acceleration (UA) event, the first instance where participant made any sort of overt behavior in response to the UA event (i.e., accelerator release, hovering the foot back and forth between pedals, etc.), the time at which participants first depressed the brake pedal, and the time at which secondary response behaviors, if any, occurred. From these time stamps, we were able to quantify three Response Times (RTs): event registry RT, brake RT, and secondary behavior RT. The event registry RT measures the delay associated with reacting to an UA event, the brake RT measures how long it took the participant to start to apply the brakes after the UA event had started, and the secondary behavior RT measures the time it took the participant to initiate a secondary behavior (e.g. pulling the emergency brake, shifting the transmission into neutral, etc.).

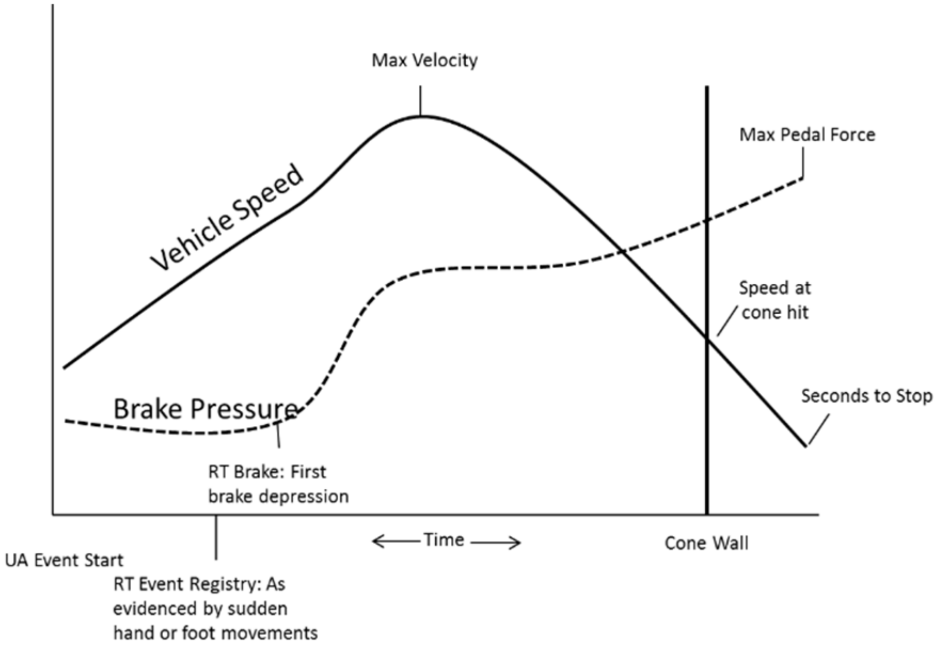


Figure 3. Schematic representation of UA coding events. RT Event Registry = time it took for the participant to "register" that a UA event occurred in milliseconds. RT Brake = time it took for participant to touch the brake after the UA event in milliseconds. Speed at cone hit = speed at which the participant hit the cones in mph. Max velocity = maximum velocity after UA event in mph. Seconds to stop = time it

took for the participant to come to a complete stop after the UA event in seconds. Max pedal force = the maximum amount of force applied on the brake pedal.

For all but one participant, the primary response to the UA event was to apply the brakes. For one subject, the primary response was to freeze up, failing to apply the brakes until the last split second before colliding with the cone wall. In addition to this primary response, many participants exhibited a secondary response such as: turning off the ignition, placing the car in neutral, placing the car in park, or engaging the parking brake. The variety of these responses was also recorded.

Several other behaviors were recorded, including the position of the participant's foot at the onset of the UA event (0=foot was hovering over the pedals, 1=foot was on the gas pedal, and 2=foot was on the brake pedal), the participant's primary behavior following the UA event (0=no brake, 1=brake), and whether participants pumped the brakes following the UA event. Brake behavior was coded by assigning a 0 for participants who did not pump the brakes or who applied steady pressure to the pedal, a 1 for participants who partially pumped the brakes, a 2 for those who made a clear pump, and a 3 to those who pumped the brakes insofar as lifting their foot completely off the brake pedal.

Starting at participant 21 (the commencement of the experimental condition in which a cone wall was introduced), we observed whether or not the participants hit the cone wall (0=did not hit the wall, 1= hit the wall). If the participants did hit the cone wall, the speed at which the wall was hit was recorded. Additional notes on the participants' behaviors were logged. A schematic representation of the timeline for video coding events is provided in Figure 3.

Results

UA Event

Bivariate correlations were run on the variables extracted from each UA event. This analysis included the demographic and UA event variables listed below in **Error! Reference source not found.**. Data from participants 21-82 are included in all analyses of UA event behavior.

Table 2. UA event variable names and descriptions

Variable Name	Description
Demographic (from the Driver's license)	
Gender	The participants self-reported Gender
Weight	The participant's weight in lbs.
Height	The participant's height in inches
Age	The participant's age in years
UA Event Variables	
RT Event Registry	The time it took for the participant to "register" that a UA event occurred, marked by the first motion of foot after UA event in milliseconds.
RT Brake	Time it took for participant to touch the brake after the UA event in milliseconds.
Hit Cones	Whether the participant hit the cones or not.
Speed at Cone Hit	Speed at which the participant hit the cones in mph.
Max Velocity	maximum velocity after UA event in mph.
Seconds to Stop	Time it took for the participant to come to a complete stop after the UA event in seconds.
Vehicle Control Variables	
Max Pedal Force	Measures the maximum amount of force applied on the brake pedal.

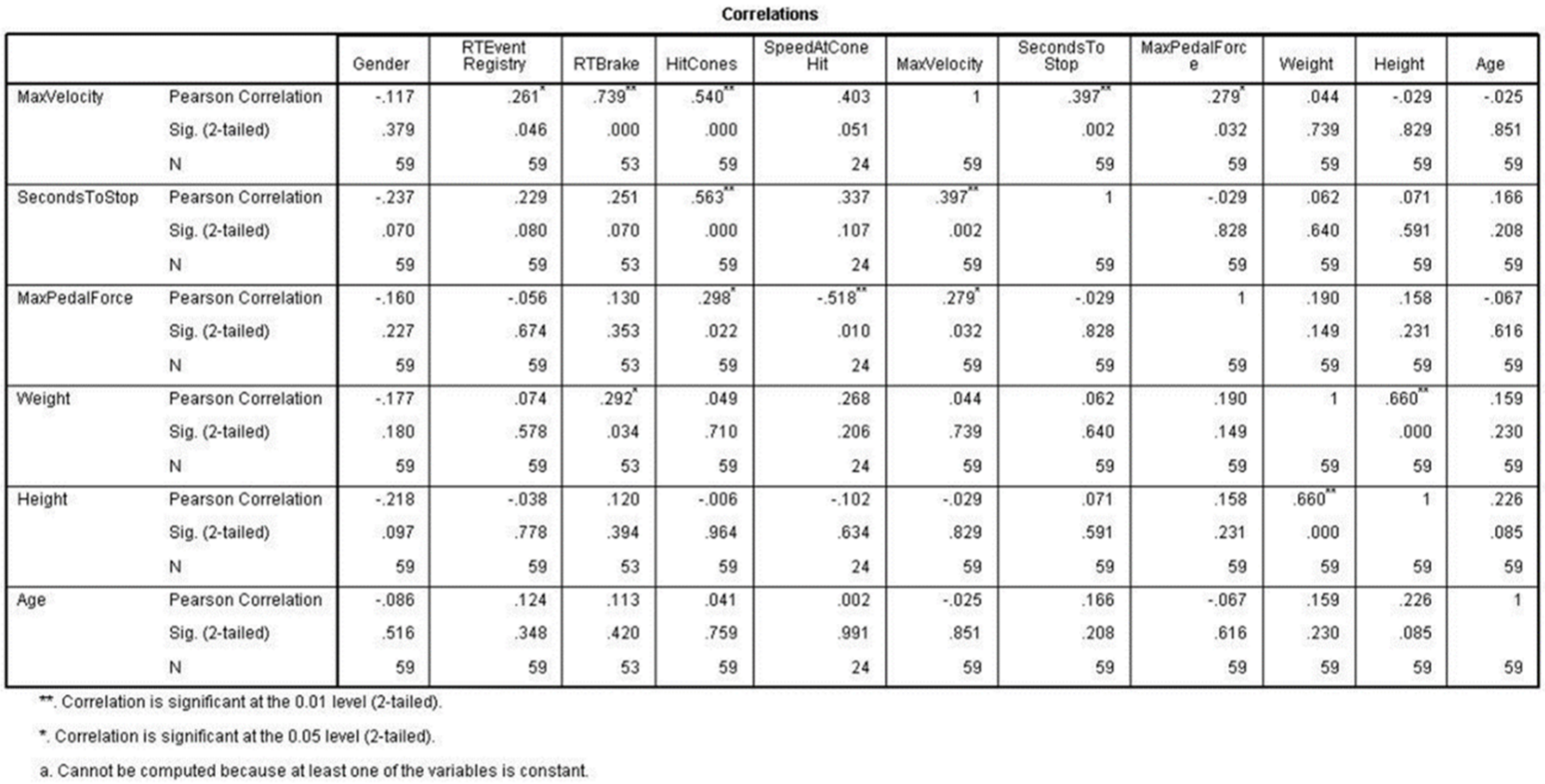
Mean and Standard deviation of RT Event Registry and RT Brake provided in Table *3*. Correlational analyses indicated that RT Event Registry was correlated with RT Brake (r=.542, p=.000 with n=53), Hit Cones (r=.339, p=.009 with n=59), Speed at Cone Hit (r=.649, p=.000 with n=24), and Max Velocity (r=.261, p=.046 with n=59). That is, delayed recognition of the UA event was associated with delays in depressing the brake, increased maximum velocity, increased likelihood of striking the cone wall, and increased vehicle speed at the time of contact with the cone wall. However, RT Event Registry time was not associated with gender, weight, height, or age. RT Brake was associated with a set of variables that were very similar to RT Event Registry. It was correlated with Hit Cones (r=.467, p=.000 with n=53), Speed at Cone Hit (r=.519, p=.011 with n=23), and Max Velocity (r=.739, p=.000 with n=53). Max Pedal Force was correlated with Hit Cones (r=.298, p=.022 with n=59), Speed at Cone Hit (r=-.518, p=.010 with n=24) and Max Velocity (r=.279, p=.032 with n=59). Max Velocity had a strong positive correlation with Hit Cones (r=.540, p=.000 with n=59). Seconds to Stop was correlated with Hit Cones (r=.563, p=.000 with n=59).

Of the demographic variables, neither Gender nor Age was associated with any of the other variables. Height and Weight were correlated (r=.660, p=.000 with n=59) and Weight was weakly correlated with RT Brake (r=.292, p=.034, n=53) and Height. This finding contrasts with later results reported in this document which indicate that women were significantly less likely than men to be able to stop their vehicle after pumping the brakes. Based on results reported later in this document, it would be expected that women would be less likely than men to be able to fully bring their car to a stop in the UA event, especially after pumping the brakes. In support of this, it was observed that participant 69, a 150 lb. 60 y/o female, was unable to bring the car to a complete stop during the UA event without intervention by the researcher in the vehicle.

Table 3. UA event response means for males and females

Gender	RT Event Registry Mean	RT Event Registry SD	RT Brake Mean	RT Brake Standard Deviation
Males	543.57	350.27	1564.00	748.84
Males > 60	536.43	182.07	1384.61	747.17
Females	702.00	498.52	1405.93	853.69
Females > 60	857.50	674.39	1856.67	1157.72

Overall, there were several significant correlations between the behavioral variables (c.f. Figure 4 and Figure 5). In general, the slower participants were to respond to the UA event by pressing their brakes, the faster their vehicle went, and the more likely they were to eventually hit the cone wall. Given the nature of the UA event, this is a very intuitive relationship. Weight was also correlated with height and height was correlated with brake response time. In this case, heavier participants were somewhat slower to apply their brakes than less heavy participants.



Correlations

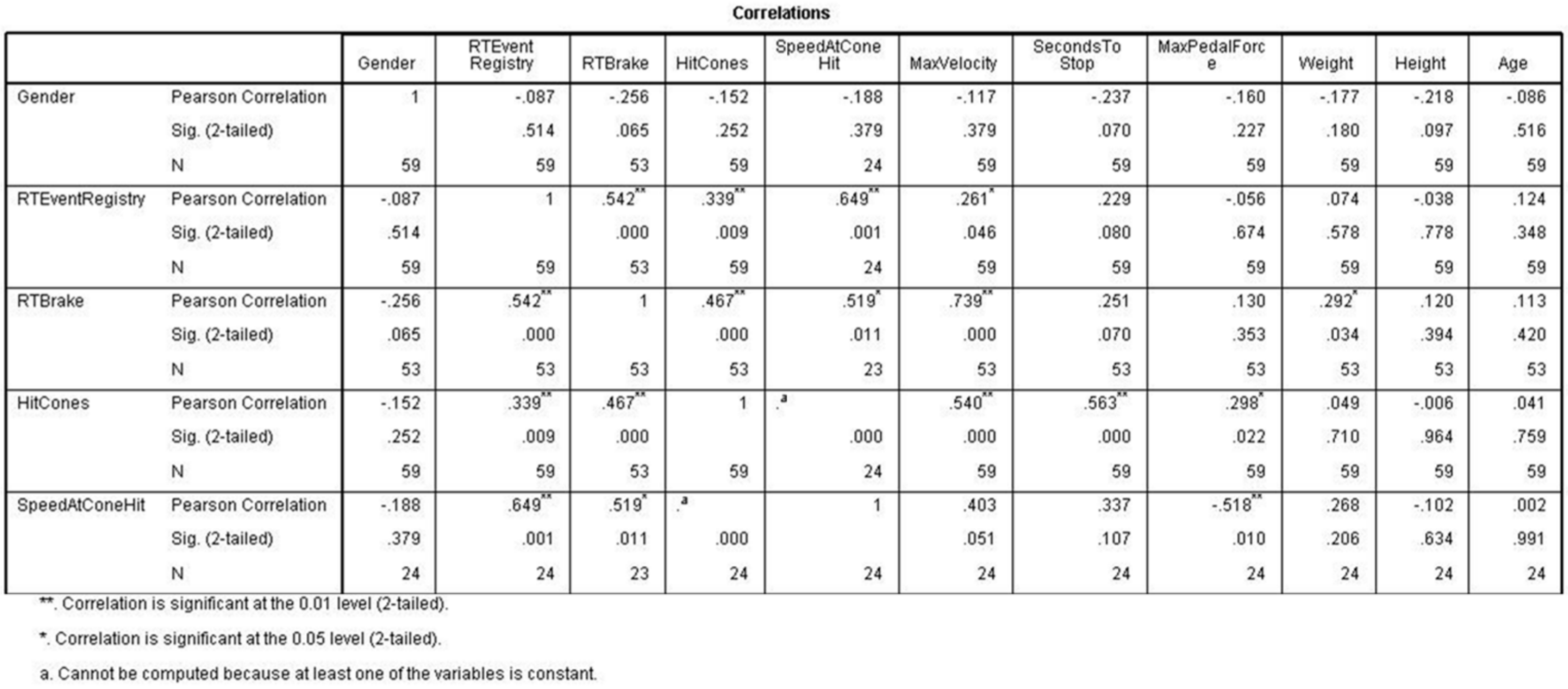
		Gender	RTEvent Registry	RTBrake	HitCones	SpeedAtCone Hit	MaxVelocity	SecondsTo Stop	MaxPedalForc e	Weight	Height	Age
MaxVelocity	Pearson Correlation	-.117	.261*	.739**	.540**	.403	1	.397**	.279*	.044	-.029	-.025
	Sig. (2-tailed)	.379	.046	.000	.000	.051		.002	.032	.739	.829	.851
	N	59	59	53	59	24	59	59	59	59	59	59
SecondsToStop	Pearson Correlation	-.237	.229	.251	.563**	.337	.397**	1	-.029	.062	.071	.166
	Sig. (2-tailed)	.070	.080	.070	.000	.107	.002		.828	.640	.591	.208
	N	59	59	53	59	24	59	59	59	59	59	59
MaxPedalForce	Pearson Correlation	-.160	-.056	.130	.298*	-.518**	.279*	-.029	1	.190	.158	-.067
	Sig. (2-tailed)	.227	.674	.353	.022	.010	.032	.828		.149	.231	.616
	N	59	59	53	59	24	59	59	59	59	59	59
Weight	Pearson Correlation	-.177	.074	.292*	.049	.268	.044	.062	.190	1	.660**	.159
	Sig. (2-tailed)	.180	.578	.034	.710	.206	.739	.640	.149		.000	.230
	N	59	59	53	59	24	59	59	59	59	59	59
Height	Pearson Correlation	-.218	-.038	.120	-.006	-.102	-.029	.071	.158	.660**	1	.226
	Sig. (2-tailed)	.097	.778	.394	.964	.634	.829	.591	.231	.000		.085
	N	59	59	53	59	24	59	59	59	59	59	59
Age	Pearson Correlation	-.086	.124	.113	.041	.002	-.025	.166	-.067	.159	.226	1
	Sig. (2-tailed)	.516	.348	.420	.759	.991	.851	.208	.616	.230	.085	
	N	59	59	53	59	24	59	59	59	59	59	59

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

a. Cannot be computed because at least one of the variables is constant.

Figure 4. Correlations between behavioral variables in the UA event



Correlations

		Gender	RTEvent Registry	RTBrake	HitCones	SpeedAtCone Hit	MaxVelocity	SecondsTo Stop	MaxPedalForce	Weight	Height	Age
Gender	Pearson Correlation	1	-.087	-.256	-.152	-.188	-.117	-.237	-.160	-.177	-.218	-.086
	Sig. (2-tailed)		.514	.065	.252	.379	.379	.070	.227	.180	.097	.516
	N	59	59	53	59	24	59	59	59	59	59	59
RTEventRegistry	Pearson Correlation	-.087	1	.542**	.339**	.649**	.261*	.229	-.056	.074	-.038	.124
	Sig. (2-tailed)	.514		.000	.009	.001	.046	.080	.674	.578	.778	.348
	N	59	59	53	59	24	59	59	59	59	59	59
RTBrake	Pearson Correlation	-.256	.542**	1	.467**	.519*	.739**	.251	.130	.292*	.120	.113
	Sig. (2-tailed)	.065	.000		.000	.011	.000	.070	.353	.034	.394	.420
	N	53	53	53	53	23	53	53	53	53	53	53
HitCones	Pearson Correlation	-.152	.339**	.467**	1	.^{a}	.540**	.563**	.298*	.049	-.006	.041
	Sig. (2-tailed)	.252	.009	.000		.000	.000	.000	.022	.710	.964	.759
	N	59	59	53	59	24	59	59	59	59	59	59
SpeedAtConeHit	Pearson Correlation	-.188	.649**	.519*	.^{a}	1	.403	.337	-.518**	.268	-.102	.002
	Sig. (2-tailed)	.379	.001	.011	.000		.051	.107	.010	.206	.634	.991
	N	24	24	23	24	24	24	24	24	24	24	24

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

a. Cannot be computed because at least one of the variables is constant.

Figure 5. Correlations between behavioral variables in the UA event

During the UA event, 34 participants were able to bring their vehicle to a stop before striking the cone wall, and 2 participants were able to maneuver their vehicle to the right or left of the cone wall in order to avoid running over the cones. However, 24 participants were unable to bring their vehicle to a stop prior to the cone wall, one of whom did not make any effort to slow the vehicle until just before striking the cone wall at 40mph (c.f. Figure 6).

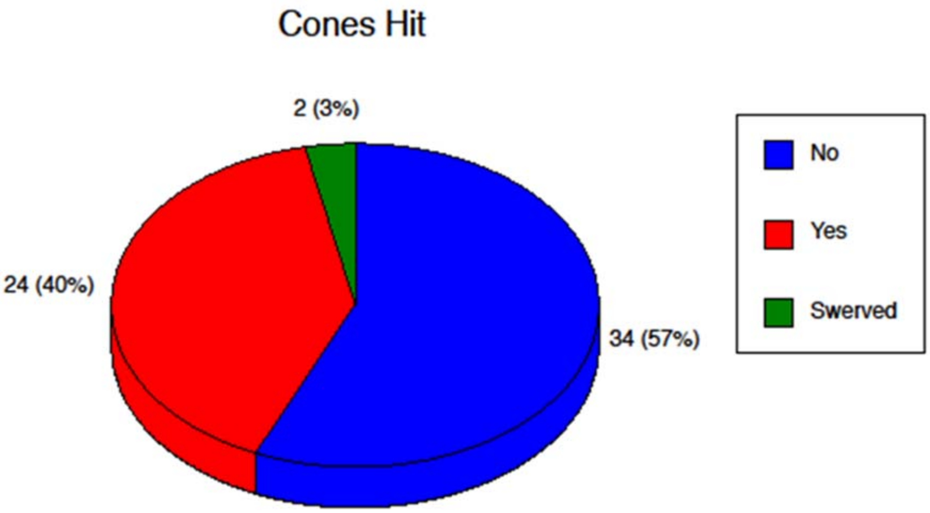


Figure 6. Breakdown of frequency of cone wall strikes.

In addition to applying their brakes, a number of participants made secondary efforts to control the UA event. This included: moving both hands to the wheel, shifting the vehicle into neutral, shifting the vehicle into park, turning off the ignition, and a variety of other behaviors (e.g., turning on the windshield wipers, grabbing the parking brake, making an movement toward to the gear shifter but doing nothing, etc.). The frequency of these behaviors is listed in Figure 7.

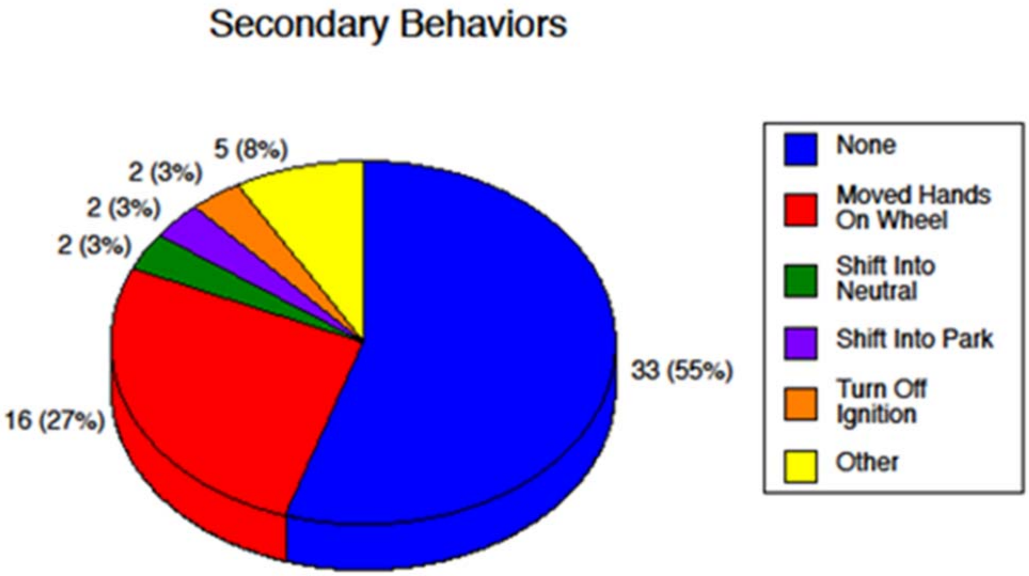


Figure 7. Frequency and types of secondary behaviors that were observed after braking

UA events were also coded for instances of brake pumping. Based on preliminary analyses, it was determined that an unambiguous or quantitative definition of brake pumping is beyond the scope of this report. From the video, we observed that some participants exhibit a clear and complete release of the brake, while others exhibited a more shallow release that did not result in their foot coming off the pedal. Still others, exhibited a slight reversal of pedal pressure that resulted in a loss of vacuum but did not look as if they pumped their brakes.

Along these lines, incidences of brake pumping were classified using 3 categories, these were:

- Partial: Defined as a slight release of the brake that, while visible in the video, resulted in subjectively less than a 10% release of braking pressure.
- Clear: Defined as a clear release of the brake pedal where the foot **did not** come all the way off the brake pedal.
- Complete: Defined as a clear release of the brake pedal where the foot **did** come all the way off the pedal.

Given that a satisfactory quantitative definition of pumping was not found, the full braking profiles of participants who exhibited either a Clear or Complete pump are provided in a Figures 10-21 below.

In total, nearly half of the participants exhibited some brake pumping behavior in response to the surprise UA event (Purple plus Green plus Red on the pie chart). Six participants exhibited behavior that was identified as a “clear” pump, and 5 participants exhibited behavior that was coded as a “complete” pump (c.f. Figure 8).

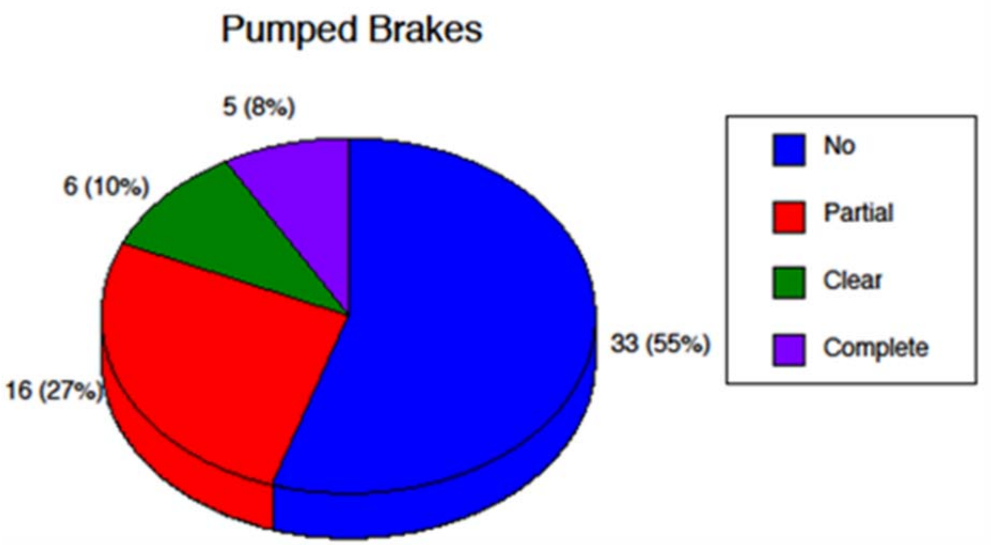


Figure 8. Frequency of UA events where participants braking was characterized as “pumping”.

In order to gain a better understanding of the types and variety of brake fluctuations that were observed, time series charts are provided for each of the 11 participants that were identified as exhibiting either a “clear” or “complete” brake pump. These analyses are presented in Figure 9 - Figure 20. Two variables are plotted in each of these charts, they are: Gain and Brake Depression Force in pounds.

Gain is a ratio of Master Cylinder Pressure to Brake Pedal Force or formally (Gain = Master Cylinder Pressure/ Brake Depression Force). Alternatively, this formula could be written as: Gain * Brake Depression Force = Master Cylinder Pressure. In this way, the Gain is the Brake Depression Force Multiplier that returns a known Master Cylinder Pressure.

For reference, Figure 9 plots the Gain and Brake Depression Force for a participant that immediately applied their brakes at a fairly constant pressure. In each of these charts, the leftmost Y axis provides the scale for interpreting the magnitude of Brake Depression Force. The Rightmost Y axis provides the scale for interpreting the Gain.

The primary purpose of these figures is to illustrate the effect that letting off the brake often had on the Gain. In the figure legend, the subject number is listed in parenthesis with a dash (-) and then either a 2 or 3. Participant numbers that contain a “-2” were categorized as clear pumps in the video. Participant numbers that are followed by a “-3” were categorized as Complete pumps in the video.

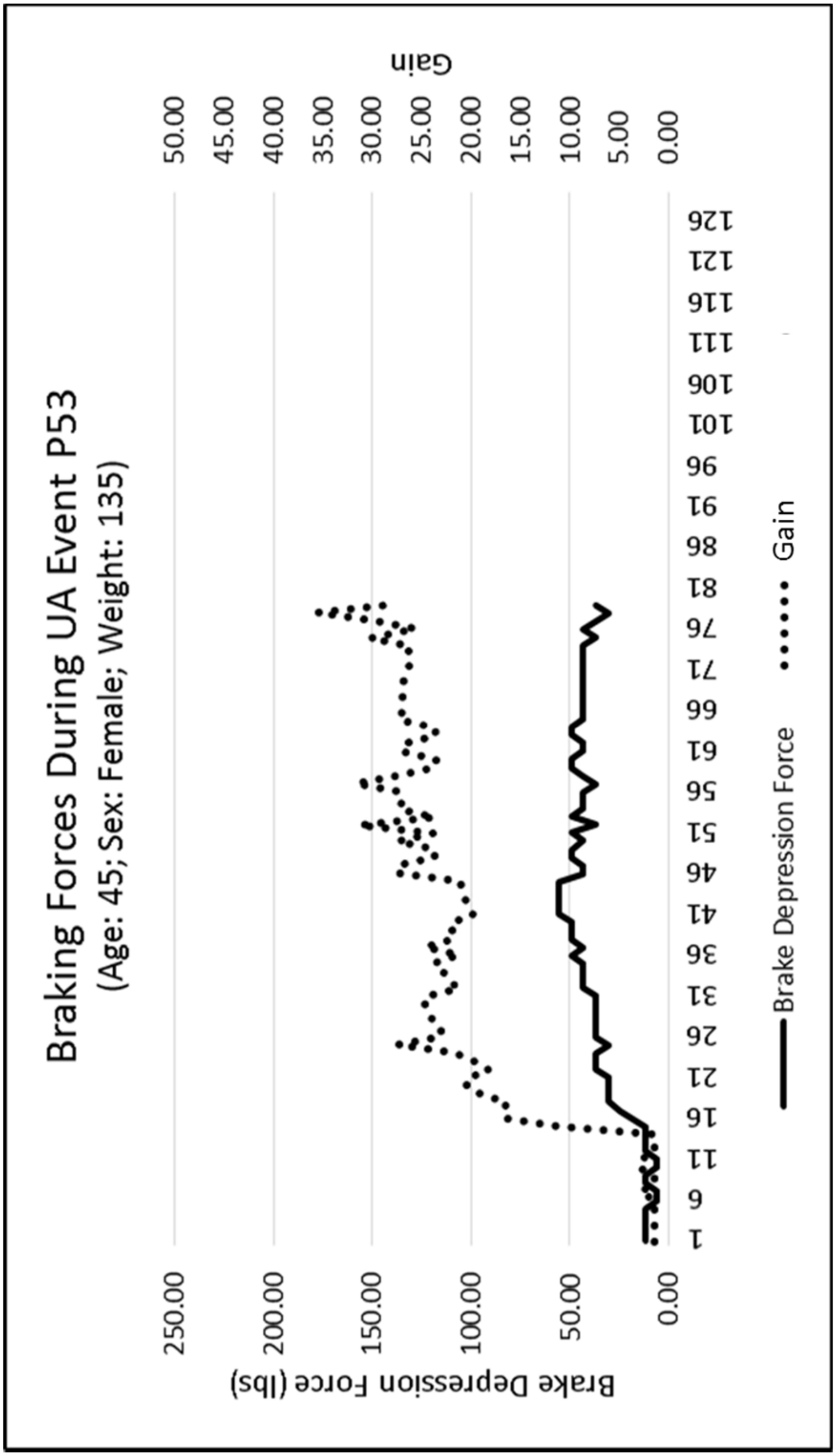


Figure 9. Reference braking plot from UA event where participant did not pump their brakes and stopped prior to hitting the cone wall (Participant 53).

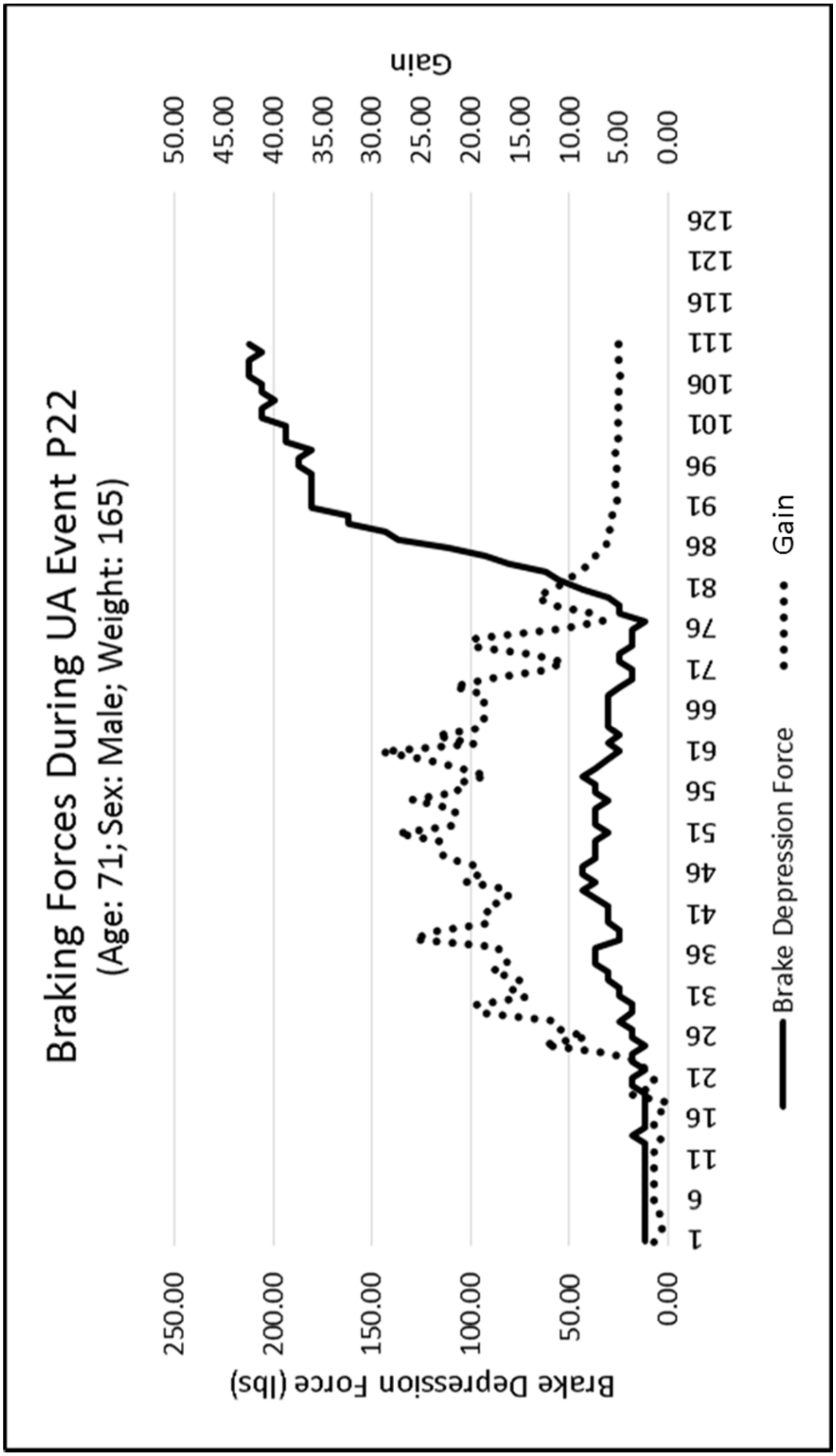


Figure 10. Time series of braking behavior and forces during a brake pump (Participant 22 - 2).

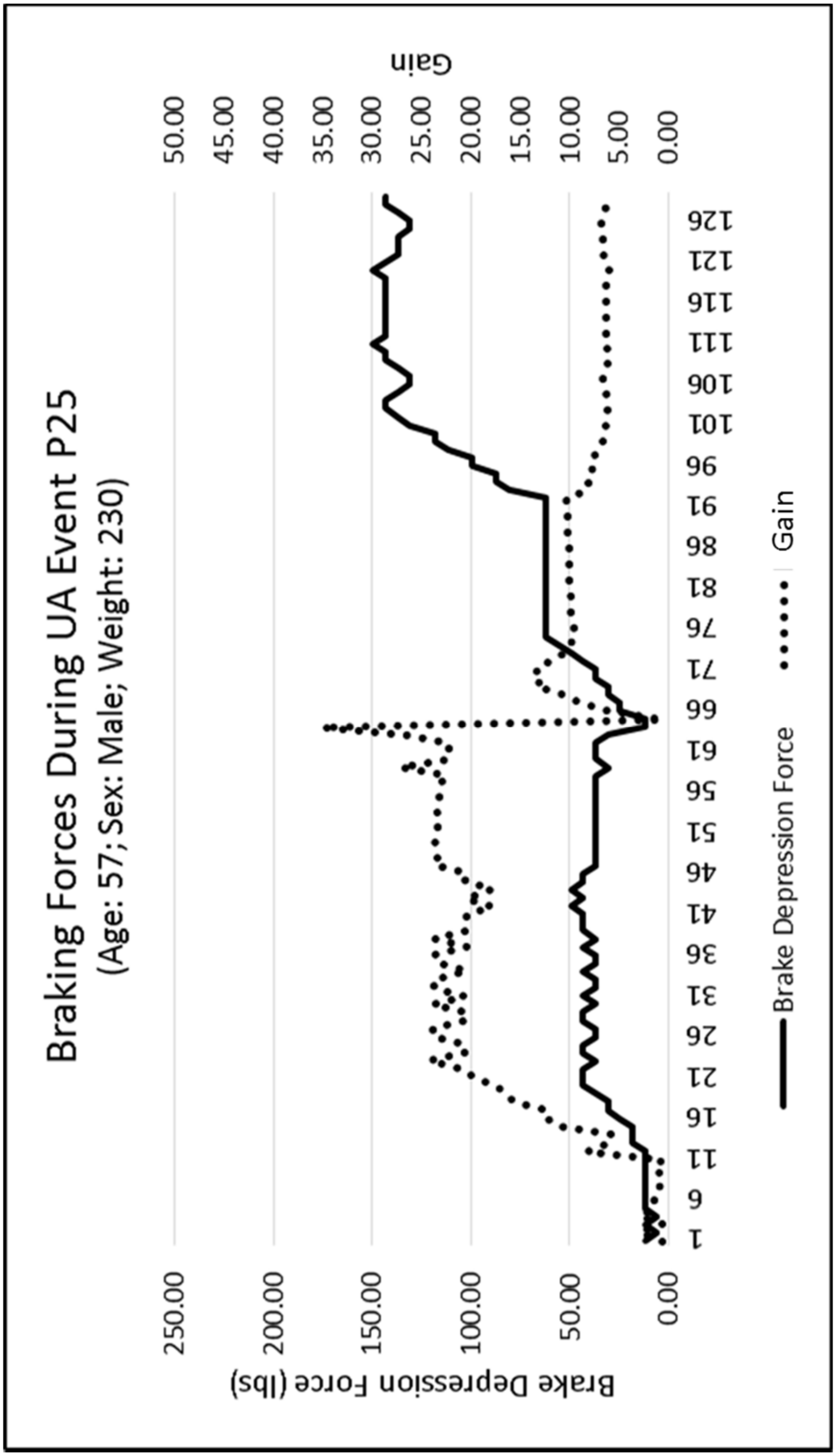


Figure 11. Time series of braking behavior and forces during a brake pump (Participant 25 - 3).

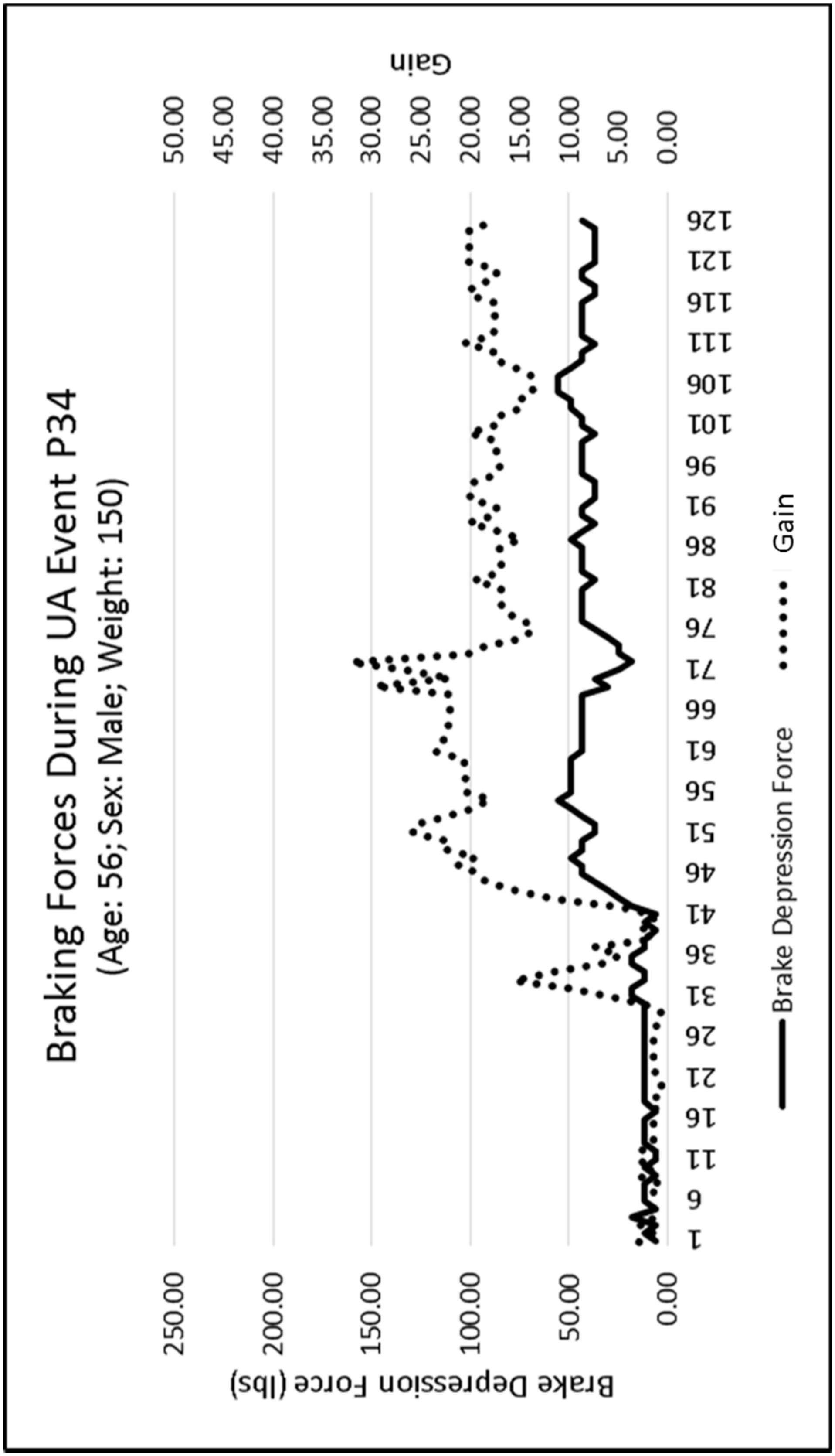


Figure 12. Time series of braking behavior and forces during a brake pump (Participant 34 - 2).

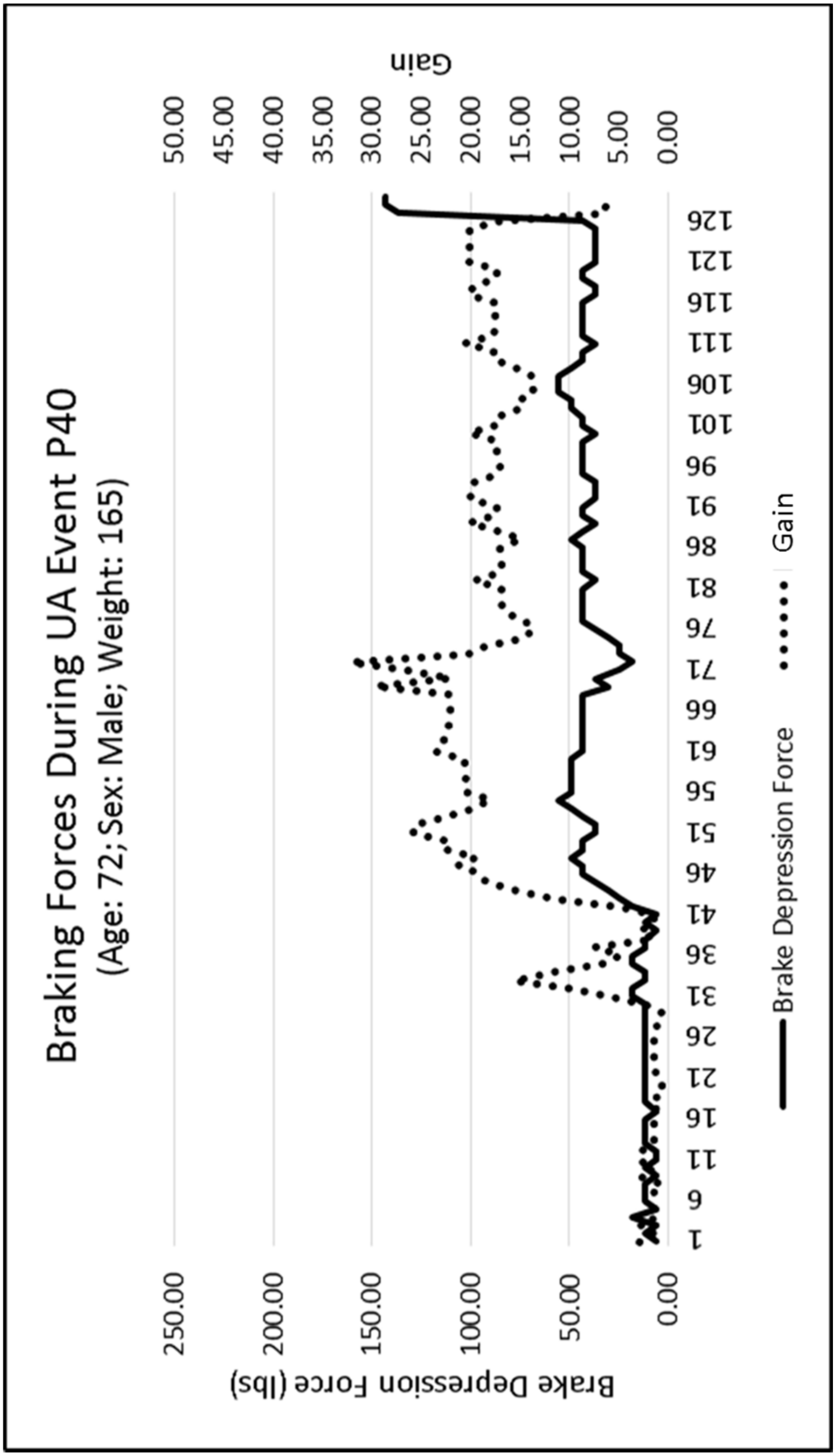


Figure 13. Time series of braking behavior and forces during a brake pump (Participant 40 - 2).

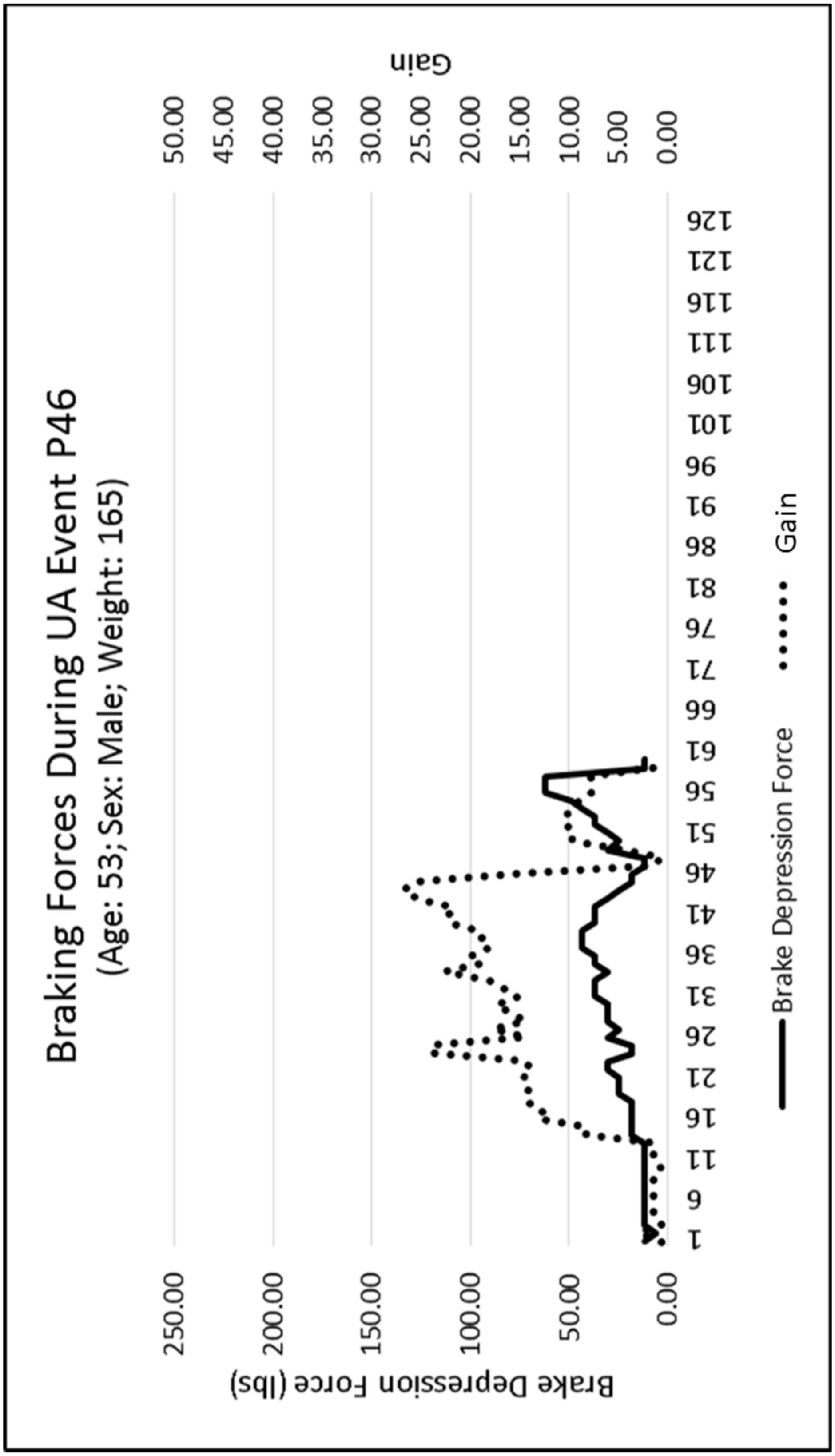


Figure 14. Time series of braking behavior and forces during a brake pump (Participant 46 - 3*).*

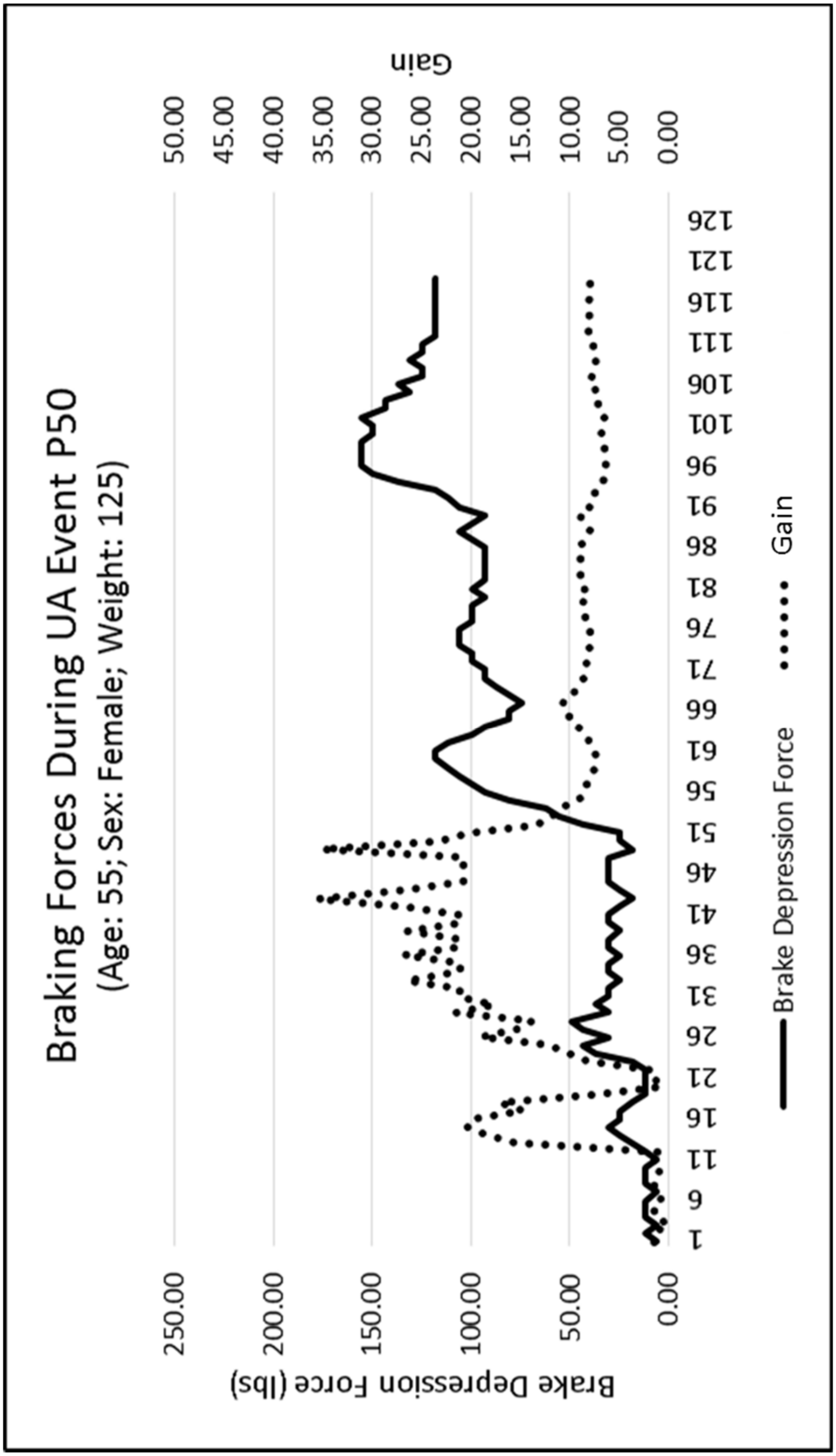


Figure 15. Time series of braking behavior and forces during a brake pump (Participant 50 - 3).

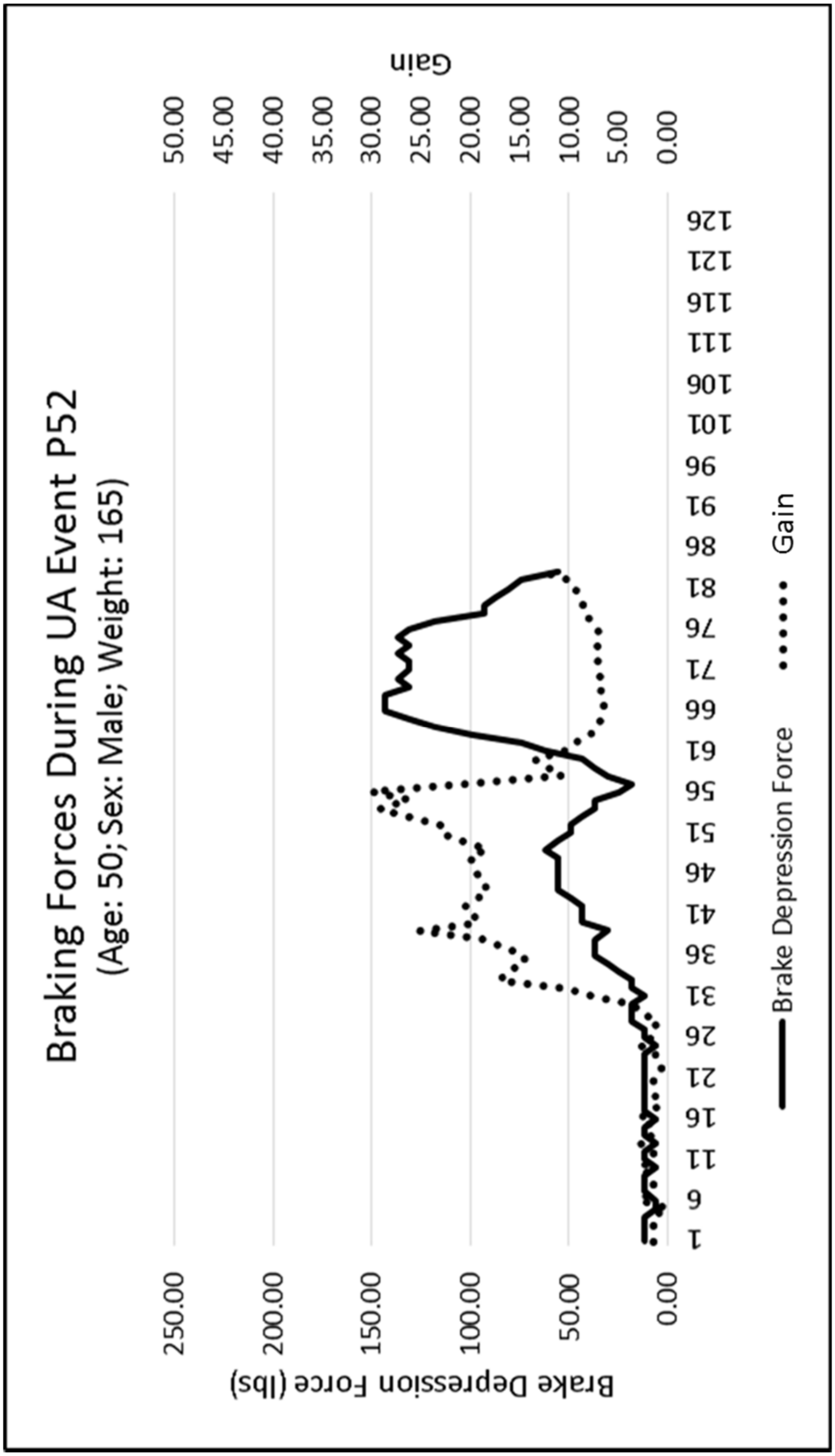


Figure 16. Time series of braking behavior and forces during a brake pump (Participant 52 - 2).

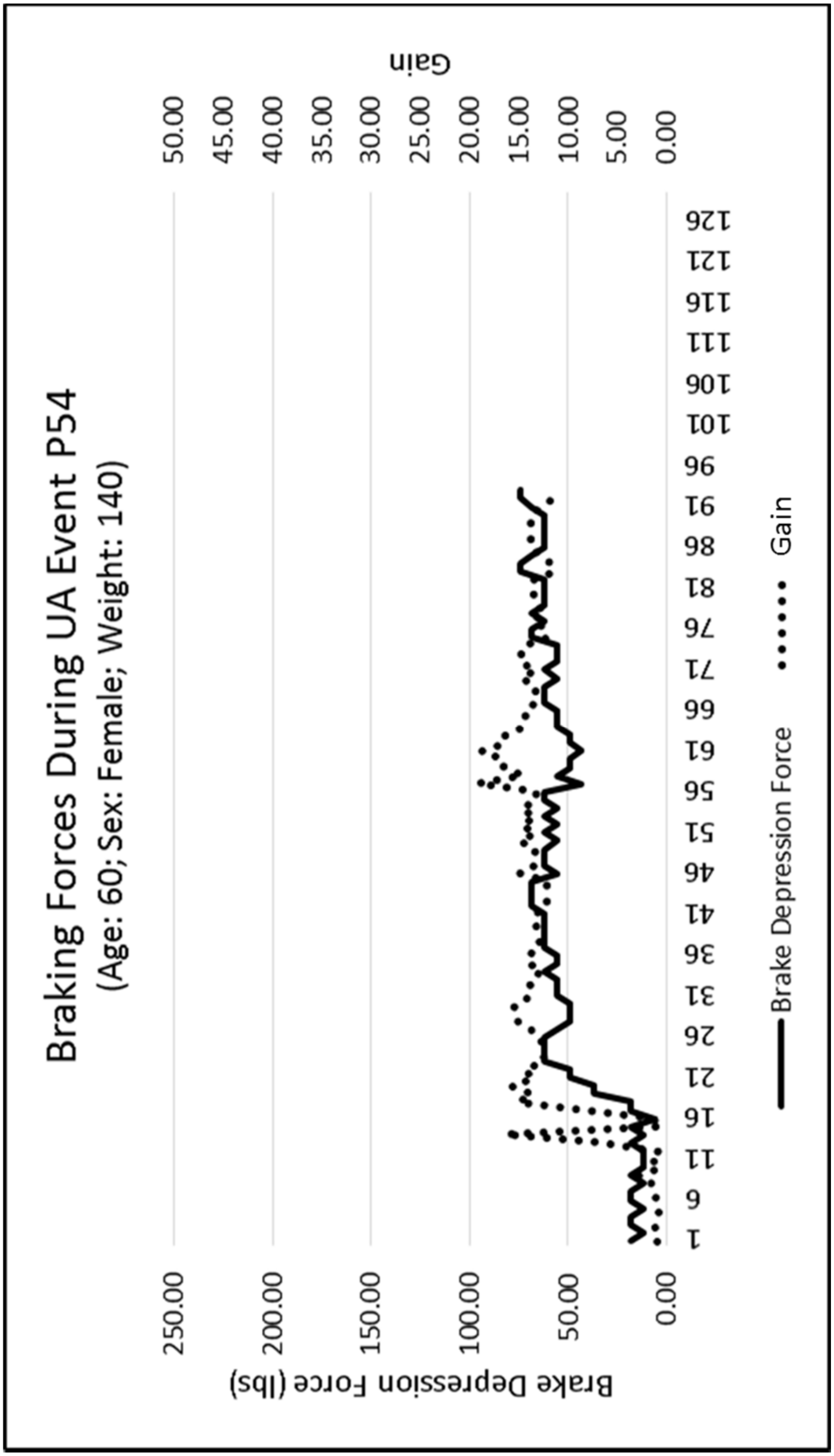


Figure 17. Time series of braking behavior and forces during a brake pump (Participant 54 - 3).

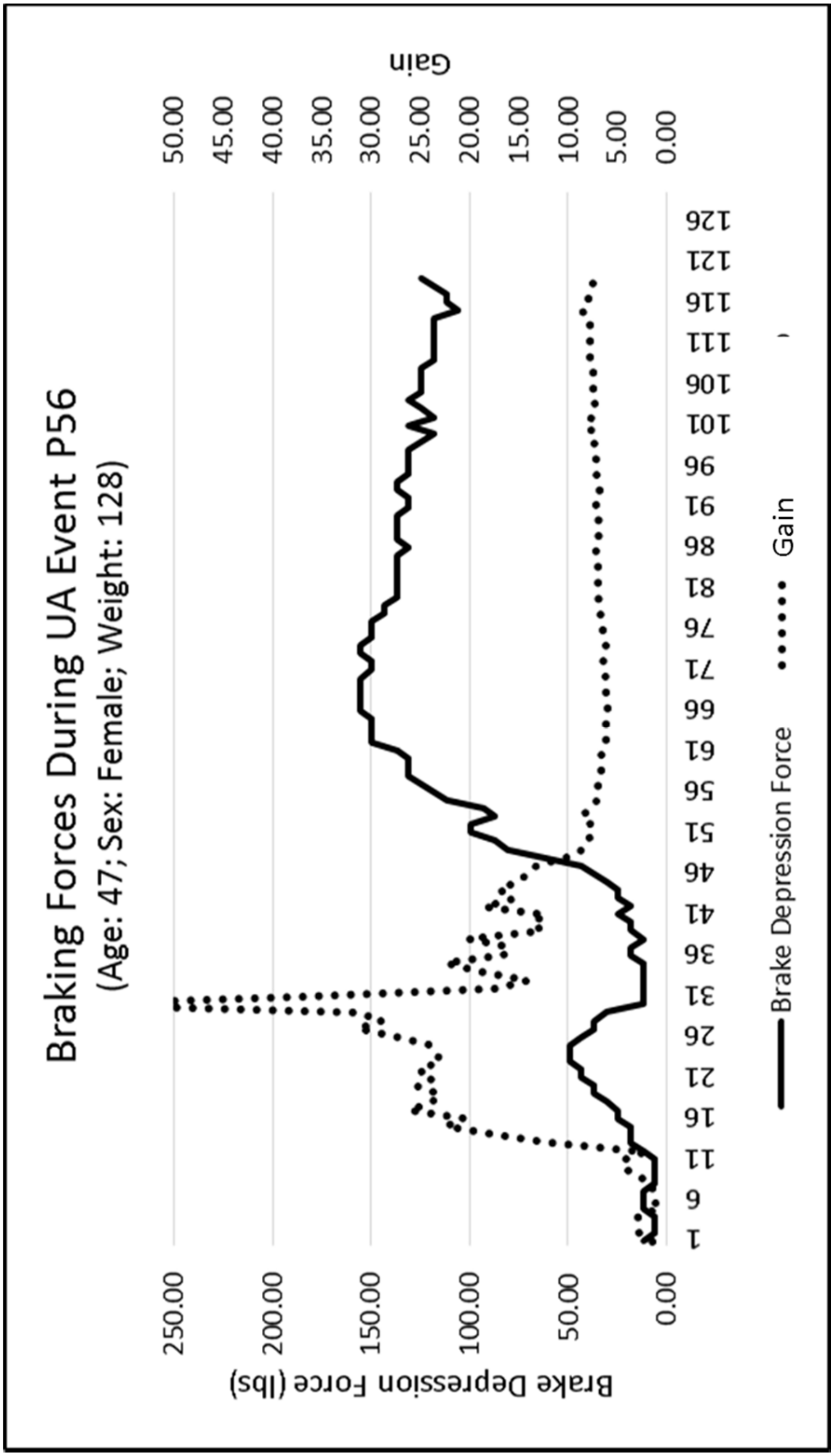


Figure 18. Time series of braking behavior and forces during a brake pump (Participant 56 - 2).

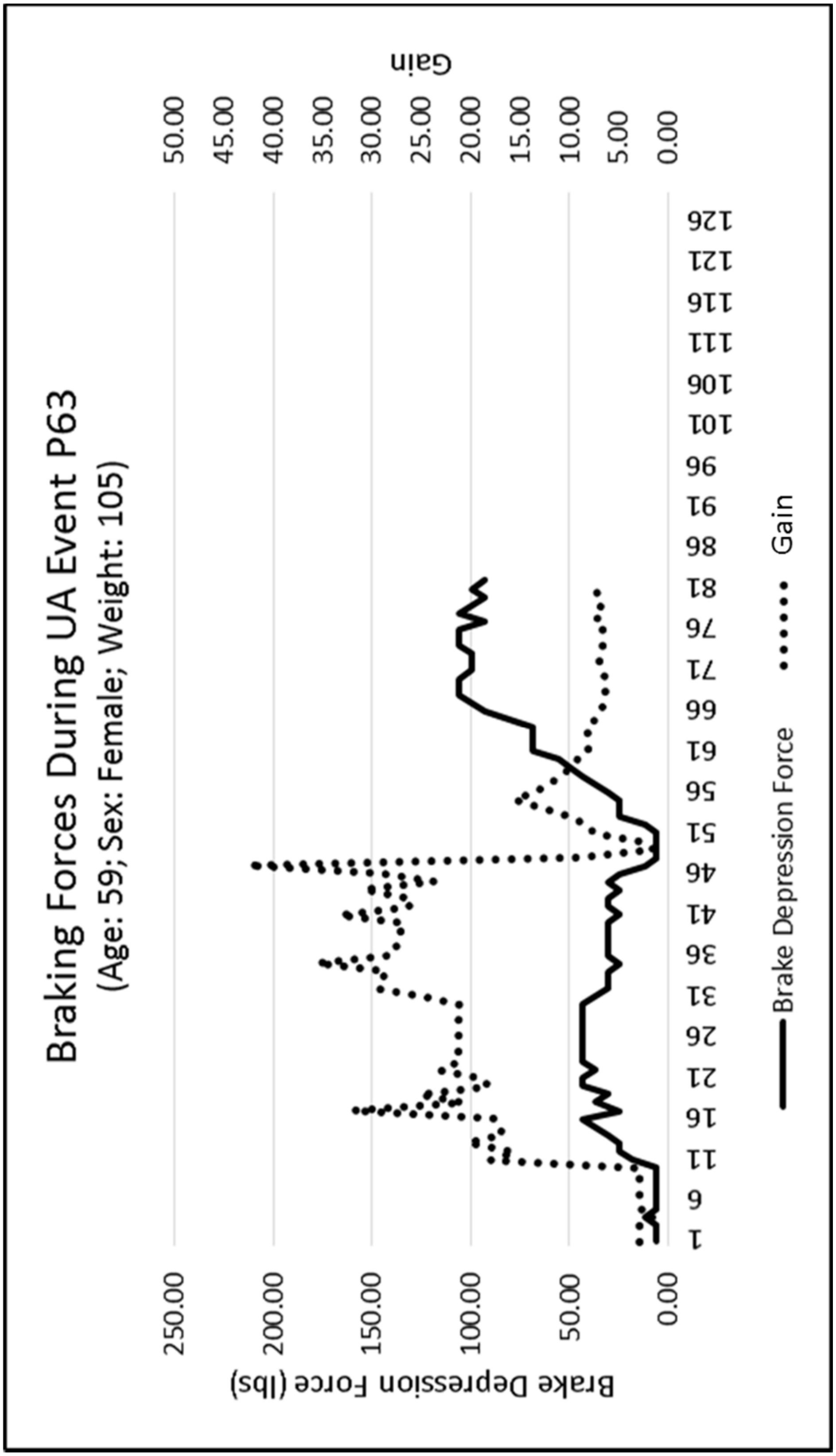


Figure 19. Time series of braking behavior and forces during a brake pump (Participant 63 - 3).

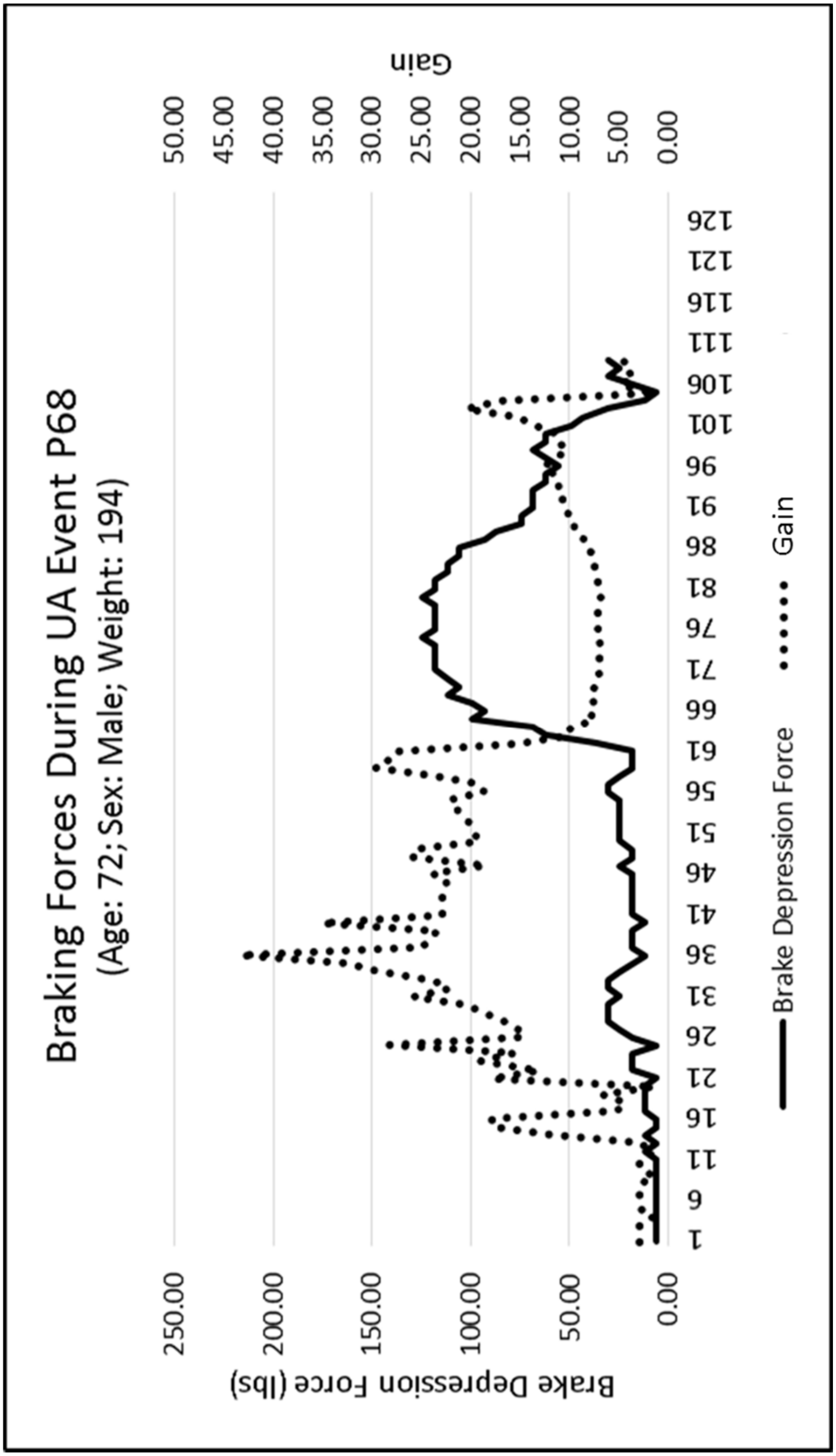


Figure 20. Time series of braking behavior and forces during a brake pump (Participant 68 - 2).

A final analysis looked at those participants that lifted their foot completely off the pedal for long enough to both turn off the rear brake light and lead to a depletion in master cylindar pressure equal to no pressure. Among these 4 participants, 2 had their foot off for 200ms, 1 had their foot off for 300ms, and the final had their foot off for 400ms. These quick and complete pumps all came within the first 6.4 seconds after the event.

Participant number	Seconds after UA onset	Total time off brake
25	6.4	100ms
34	3.7	400ms
46	4.6	200ms
50	1.9	300ms
54	1.4	200ms

Figure 21. Brake pedal release duration after during UA event

Deceleration Events

Similar to the analysis of the UA event, deceleration events were first subject to a series of bivariate correlations. This approach is useful to flag important relationships for more fine-grained analysis. Variable codes used in these analyses are provided in Figure 22. Analyses of deceleration events were completed on the full 82 subjects that participated in this research.

Variable Name	Description
Gender	The self-reported gender identity of participants
Age	The age of participants that was listed on their government issued identification
Driving Experience	The self-reported number of years that participants had been driving
Height	The height of participants in inches
Weight	Weight in pounds
Decel	Vehicle deceleration rate calculated as the linear deceleration rate between the first valid vehicle speed under 30mph and the last valid vehicle speed at or above 0mph
BrakeMean	The average measured force on the brake pedal
VacMean	The average pressure in the brake vacuum system
CylMean	The average pressure in the master braking cylinder

Figure 22. Deceleration Event variable names and descriptions

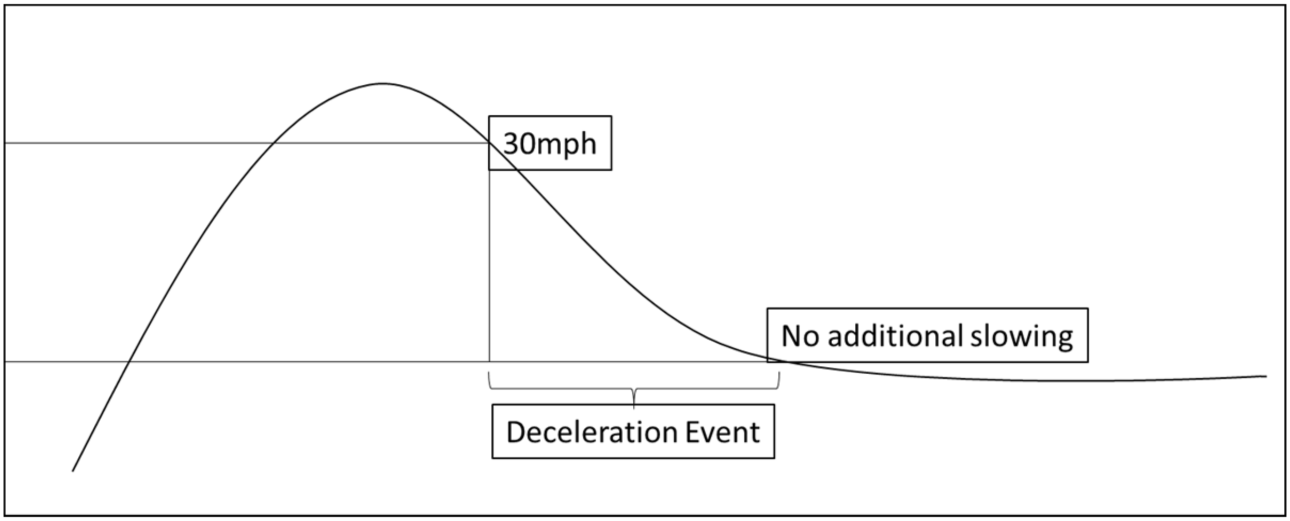


Figure 23. Deceleration event schematic definition

The deceleration event was defined as the instance where participants slowed their vehicle below 30mph after having accelerated from 0mph. The lower end of the event was defined as either 1) the instant that the participant vehicle re-attained 0mph or the instant where the participant vehicle began to gain speed due to a participant being unable to bring the vehicle to a complete stop (See Figure 23) .

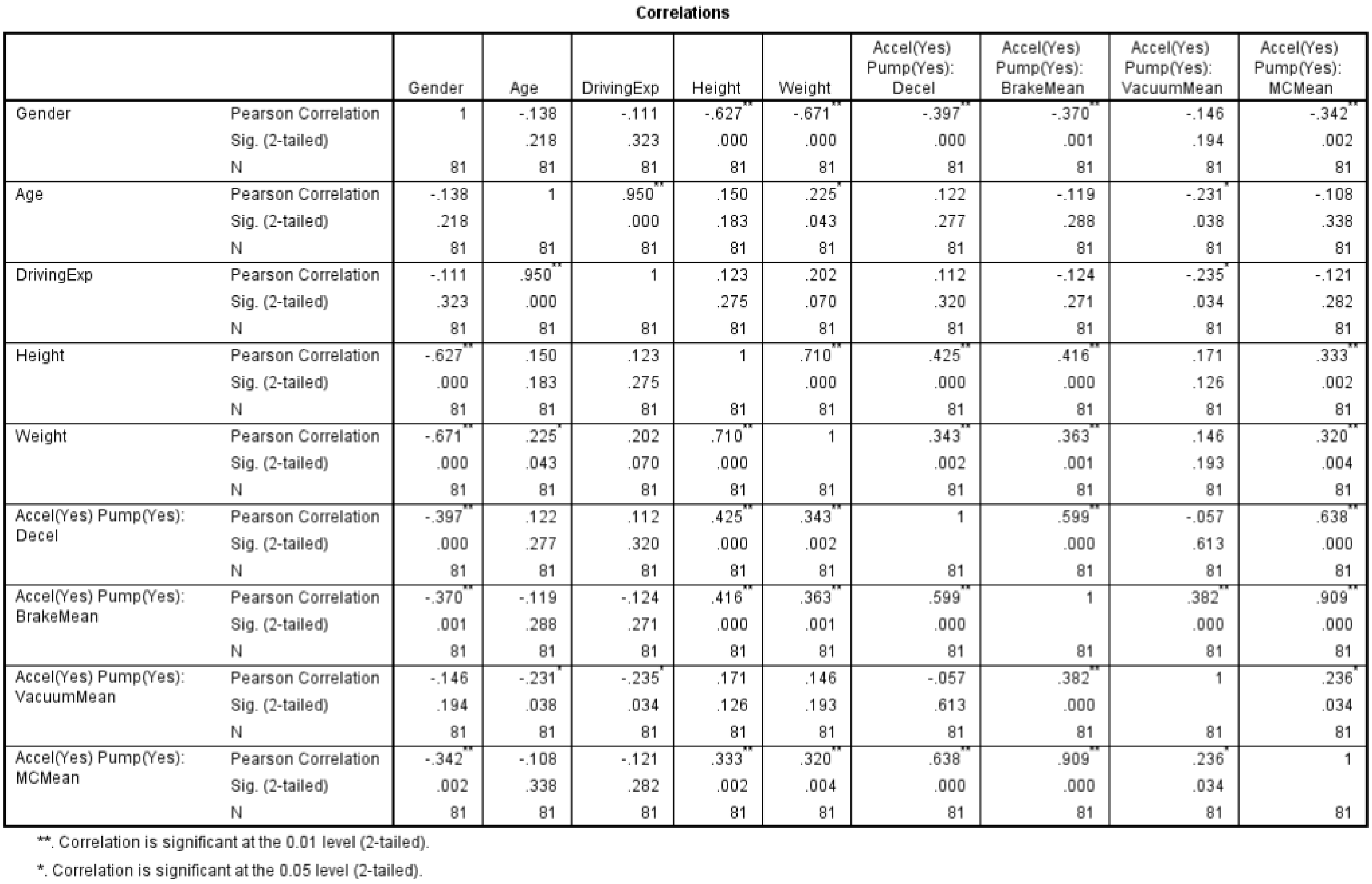
Across each of the 4 braking conditions (Throttle Open, Brake Pump; Throttle Open, No Pump; Throttle Closed, Brake Pump; and Throttle Closed, No Pump) Gender was found to typically correlate with height, weight, deceleration rate, mean brake pedal force, and mean master cylinder pressure. This was especially true in the Throttle Open conditions. Not surprisingly, mean brake pedal force was highly correlated with deceleration rate, and master cylinder pressure. No effect of age was observed, with the exception that older drivers in our sample were slightly taller than our younger drivers. In summary, the women in our study were typically not as tall, not as heavy, and could not apply the brakes as forcefully as the men. This led to a reduced rate of deceleration for women compared to men (c.f., Figure 24, Figure 25, Figure 26, and Figure 27).

In the Throttle-Open, Brake-Pump deceleration event, it was observed that 36/39 males were able to bring the vehicle to a complete stop. Contrast that with the fact that only 25/43 females in this study were able to bring the vehicle to a complete stop in the Throttle-Open, Brake-Pump deceleration event. A Chi-Square analysis between gender and stopping ability indicated that the association was significant (χ^2 (1) = 12.53, $p < .001$). Odds ratios from this event indicated that the odds of females being unable to stop the vehicle were 9.36 times higher than males when the vehicle was accelerating and the brake vacuum was depleted. Table 4 reports the contingency table used to calculate Chi Square and the odds ratio. Figure 28 presents the frequency of male and female participants' ability to stop the vehicle during uncontrolled acceleration.

Table 4

Chi Square Contingency Table of Stopping Likelihood for Males and Females in the Throttle Open, Brake Pump Deceleration Event

Gender		Stopped	Couldn't Stop	Total
Male	Count	36	3	39
	Expected Count	29.0	10.0	39.0
	% within Gender	92.3%	7.7%	100.0%
	% within Couldn't Stop	59.0%	14.3%	47.6%
	% of Total	43.9%	3.7%	47.6%
	Std. Residual	1.3	-2.2	
Female	Count	25	18	43
	Expected Count	32.0	11.0	43.0
	% within Gender	58.1%	41.9%	100.0%
	% within Couldn't Stop	41.0%	85.7%	52.4%
	% of Total	30.5%	22.0%	52.4%
	Std. Residual	-1.2	2.1	
Total	Count	61	21	82
	Expected Count	61.0	21.0	82.0
	% within Gender	74.4%	25.6%	100.0%
	% within Couldn't Stop	100.0%	100.0%	100.0%
	% of Total	74.4%	25.6%	100.0%



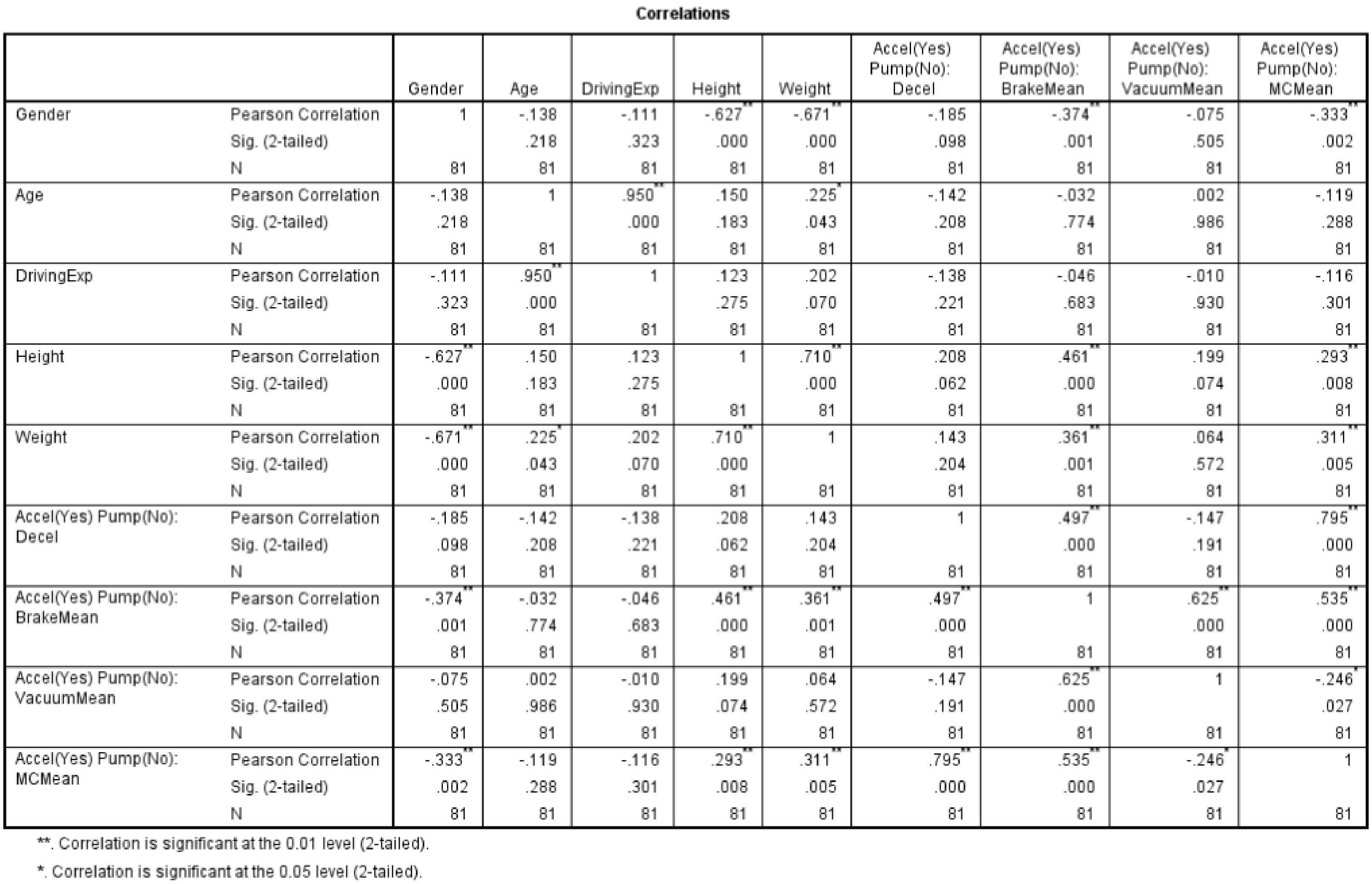
Correlations

		Gender	Age	DrivingExp	Height	Weight	Accel(Yes) Pump(Yes): Decel	Accel(Yes) Pump(Yes): BrakeMean	Accel(Yes) Pump(Yes): VacuumMean	Accel(Yes) Pump(Yes): MCMean
Gender	Pearson Correlation	1	-.138	-.111	-.627**	-.671**	-.397**	-.370**	-.146	-.342**
	Sig. (2-tailed)		.218	.323	.000	.000	.000	.001	.194	.002
	N	81	81	81	81	81	81	81	81	81
Age	Pearson Correlation	-.138	1	.950**	.150	.225*	.122	-.119	-.231*	-.108
	Sig. (2-tailed)	.218		.000	.183	.043	.277	.288	.038	.338
	N	81	81	81	81	81	81	81	81	81
DrivingExp	Pearson Correlation	-.111	.950**	1	.123	.202	.112	-.124	-.235*	-.121
	Sig. (2-tailed)	.323	.000		.275	.070	.320	.271	.034	.282
	N	81	81	81	81	81	81	81	81	81
Height	Pearson Correlation	-.627**	.150	.123	1	.710**	.425**	.416**	.171	.333**
	Sig. (2-tailed)	.000	.183	.275		.000	.000	.000	.126	.002
	N	81	81	81	81	81	81	81	81	81
Weight	Pearson Correlation	-.671**	.225*	.202	.710**	1	.343**	.363**	.146	.320**
	Sig. (2-tailed)	.000	.043	.070	.000		.002	.001	.193	.004
	N	81	81	81	81	81	81	81	81	81
Accel(Yes) Pump(Yes): Decel	Pearson Correlation	-.397**	.122	.112	.425**	.343**	1	.599**	-.057	.638**
	Sig. (2-tailed)	.000	.277	.320	.000	.002		.000	.613	.000
	N	81	81	81	81	81	81	81	81	81
Accel(Yes) Pump(Yes): BrakeMean	Pearson Correlation	-.370**	-.119	-.124	.416**	.363**	.599**	1	.382**	.909**
	Sig. (2-tailed)	.001	.288	.271	.000	.001	.000		.000	.000
	N	81	81	81	81	81	81	81	81	81
Accel(Yes) Pump(Yes): VacuumMean	Pearson Correlation	-.146	-.231*	-.235*	.171	.146	-.057	.382**	1	.236*
	Sig. (2-tailed)	.194	.038	.034	.126	.193	.613	.000		.034
	N	81	81	81	81	81	81	81	81	81
Accel(Yes) Pump(Yes): MCMean	Pearson Correlation	-.342**	-.108	-.121	.333**	.320**	.638**	.909**	.236*	1
	Sig. (2-tailed)	.002	.338	.282	.002	.004	.000	.000	.034	
	N	81	81	81	81	81	81	81	81	81

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Figure 24. Throttle Open, Pump.



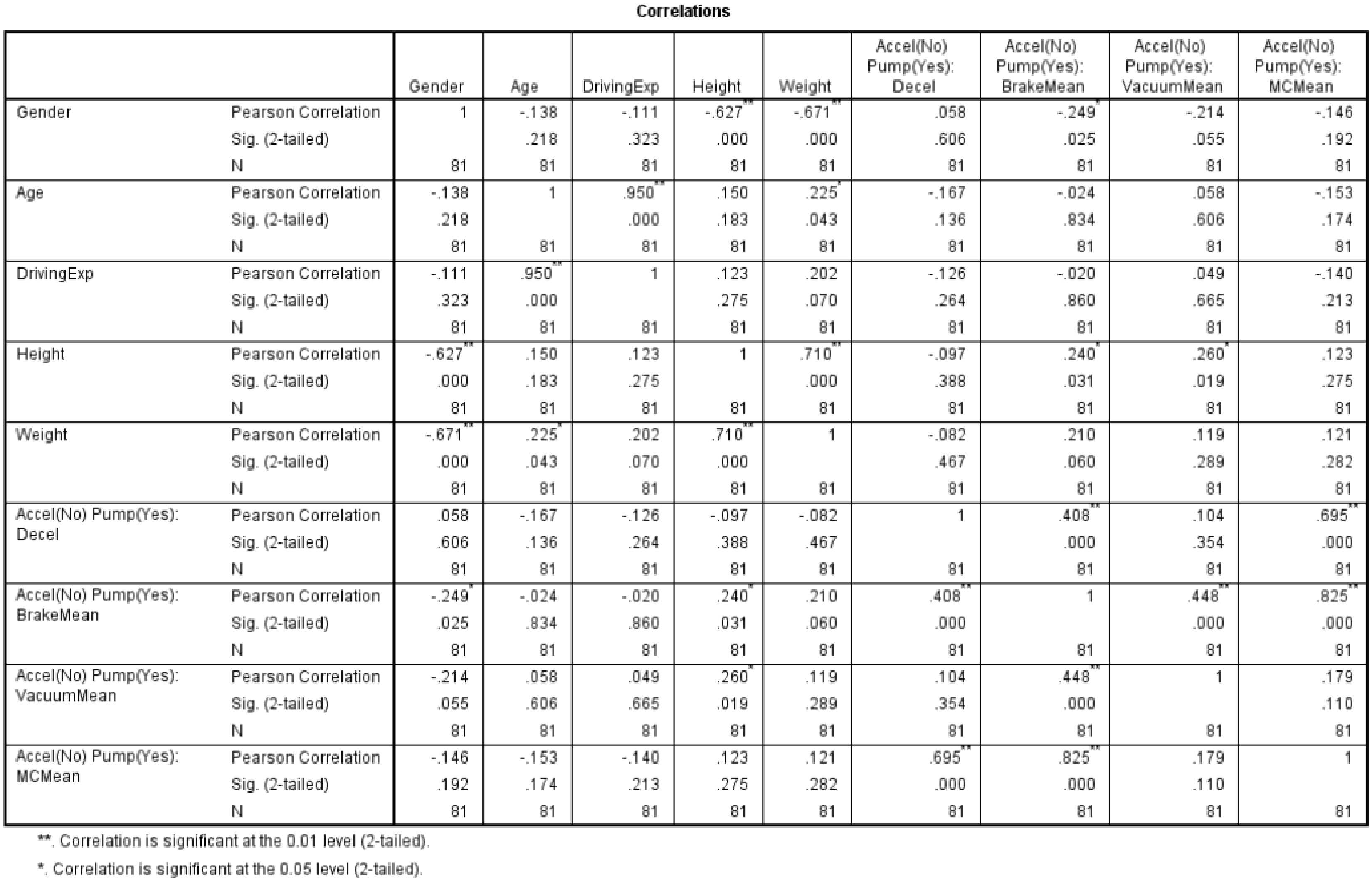
Correlations

		Gender	Age	DrivingExp	Height	Weight	Accel(Yes) Pump(No): Decel	Accel(Yes) Pump(No): BrakeMean	Accel(Yes) Pump(No): VacuumMean	Accel(Yes) Pump(No): MCMean
Gender	Pearson Correlation	1	-.138	-.111	-.627**	-.671**	-.185	-.374**	-.075	-.333**
	Sig. (2-tailed)		.218	.323	.000	.000	.098	.001	.505	.002
	N	81	81	81	81	81	81	81	81	81
Age	Pearson Correlation	-.138	1	.950**	.150	.225*	-.142	-.032	.002	-.119
	Sig. (2-tailed)	.218		.000	.183	.043	.208	.774	.986	.288
	N	81	81	81	81	81	81	81	81	81
DrivingExp	Pearson Correlation	-.111	.950**	1	.123	.202	-.138	-.046	-.010	-.116
	Sig. (2-tailed)	.323	.000		.275	.070	.221	.683	.930	.301
	N	81	81	81	81	81	81	81	81	81
Height	Pearson Correlation	-.627**	.150	.123	1	.710**	.208	.461**	.199	.293**
	Sig. (2-tailed)	.000	.183	.275		.000	.062	.000	.074	.008
	N	81	81	81	81	81	81	81	81	81
Weight	Pearson Correlation	-.671**	.225*	.202	.710**	1	.143	.361**	.064	.311**
	Sig. (2-tailed)	.000	.043	.070	.000		.204	.001	.572	.005
	N	81	81	81	81	81	81	81	81	81
Accel(Yes) Pump(No): Decel	Pearson Correlation	-.185	-.142	-.138	.208	.143	1	.497**	-.147	.795**
	Sig. (2-tailed)	.098	.208	.221	.062	.204		.000	.191	.000
	N	81	81	81	81	81	81	81	81	81
Accel(Yes) Pump(No): BrakeMean	Pearson Correlation	-.374**	-.032	-.046	.461**	.361**	.497**	1	.625**	.535**
	Sig. (2-tailed)	.001	.774	.683	.000	.001	.000		.000	.000
	N	81	81	81	81	81	81	81	81	81
Accel(Yes) Pump(No): VacuumMean	Pearson Correlation	-.075	.002	-.010	.199	.064	-.147	.625**	1	-.246*
	Sig. (2-tailed)	.505	.986	.930	.074	.572	.191	.000		.027
	N	81	81	81	81	81	81	81	81	81
Accel(Yes) Pump(No): MCMean	Pearson Correlation	-.333**	-.119	-.116	.293**	.311**	.795**	.535**	-.246*	1
	Sig. (2-tailed)	.002	.288	.301	.008	.005	.000	.000	.027	
	N	81	81	81	81	81	81	81	81	81

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Figure 25. Throttle Open, No Pump.



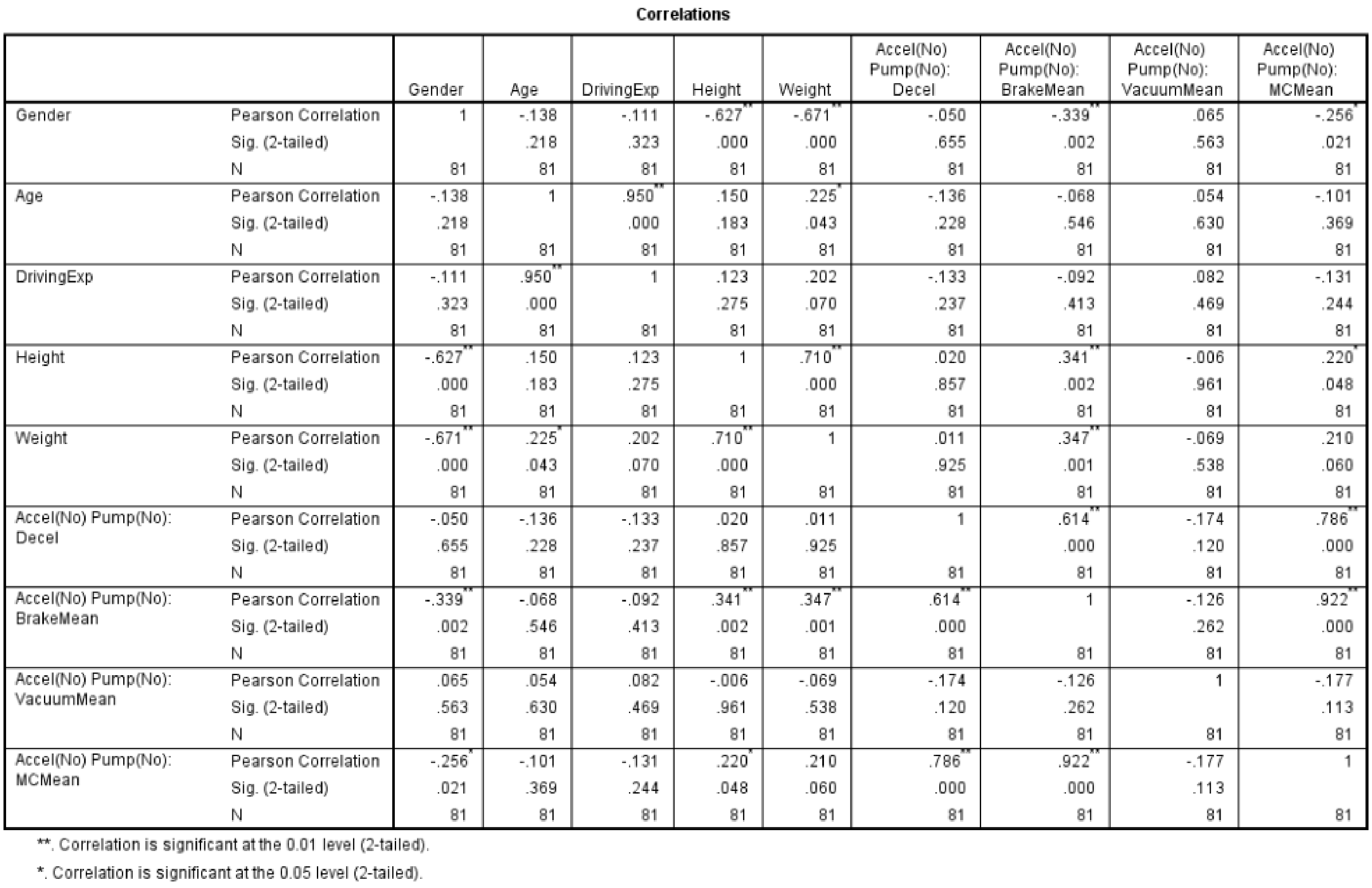
Correlations

		Gender	Age	DrivingExp	Height	Weight	Accel(No) Pump(Yes): Decel	Accel(No) Pump(Yes): BrakeMean	Accel(No) Pump(Yes): VacuumMean	Accel(No) Pump(Yes): MCMean
Gender	Pearson Correlation	1	-.138	-.111	-.627**	-.671**	.058	-.249*	-.214	-.146
	Sig. (2-tailed)		.218	.323	.000	.000	.606	.025	.055	.192
	N	81	81	81	81	81	81	81	81	81
Age	Pearson Correlation	-.138	1	.950**	.150	.225*	-.167	-.024	.058	-.153
	Sig. (2-tailed)	.218		.000	.183	.043	.136	.834	.606	.174
	N	81	81	81	81	81	81	81	81	81
DrivingExp	Pearson Correlation	-.111	.950**	1	.123	.202	-.126	-.020	.049	-.140
	Sig. (2-tailed)	.323	.000		.275	.070	.264	.860	.665	.213
	N	81	81	81	81	81	81	81	81	81
Height	Pearson Correlation	-.627**	.150	.123	1	.710**	-.097	.240*	.260*	.123
	Sig. (2-tailed)	.000	.183	.275		.000	.388	.031	.019	.275
	N	81	81	81	81	81	81	81	81	81
Weight	Pearson Correlation	-.671**	.225*	.202	.710**	1	-.082	.210	.119	.121
	Sig. (2-tailed)	.000	.043	.070	.000		.467	.060	.289	.282
	N	81	81	81	81	81	81	81	81	81
Accel(No) Pump(Yes): Decel	Pearson Correlation	.058	-.167	-.126	-.097	-.082	1	.408**	.104	.695**
	Sig. (2-tailed)	.606	.136	.264	.388	.467		.000	.354	.000
	N	81	81	81	81	81	81	81	81	81
Accel(No) Pump(Yes): BrakeMean	Pearson Correlation	-.249*	-.024	-.020	.240*	.210	.408**	1	.448**	.825**
	Sig. (2-tailed)	.025	.834	.860	.031	.060	.000		.000	.000
	N	81	81	81	81	81	81	81	81	81
Accel(No) Pump(Yes): VacuumMean	Pearson Correlation	-.214	.058	.049	.260*	.119	.104	.448**	1	.179
	Sig. (2-tailed)	.055	.606	.665	.019	.289	.354	.000		.110
	N	81	81	81	81	81	81	81	81	81
Accel(No) Pump(Yes): MCMean	Pearson Correlation	-.146	-.153	-.140	.123	.121	.695**	.825**	.179	1
	Sig. (2-tailed)	.192	.174	.213	.275	.282	.000	.000	.110	
	N	81	81	81	81	81	81	81	81	81

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Figure 26. Throttle Closed, Pump.



Correlations

		Gender	Age	DrivingExp	Height	Weight	Accel(No) Pump(No): Decel	Accel(No) Pump(No): BrakeMean	Accel(No) Pump(No): VacuumMean	Accel(No) Pump(No): MCMean
Gender	Pearson Correlation	1	-.138	-.111	-.627**	-.671**	-.050	-.339**	.065	-.256*
	Sig. (2-tailed)		.218	.323	.000	.000	.655	.002	.563	.021
	N	81	81	81	81	81	81	81	81	81
Age	Pearson Correlation	-.138	1	.950**	.150	.225*	-.136	-.068	.054	-.101
	Sig. (2-tailed)	.218		.000	.183	.043	.228	.546	.630	.369
	N	81	81	81	81	81	81	81	81	81
DrivingExp	Pearson Correlation	-.111	.950**	1	.123	.202	-.133	-.092	.082	-.131
	Sig. (2-tailed)	.323	.000		.275	.070	.237	.413	.469	.244
	N	81	81	81	81	81	81	81	81	81
Height	Pearson Correlation	-.627**	.150	.123	1	.710**	.020	.341**	-.006	.220*
	Sig. (2-tailed)	.000	.183	.275		.000	.857	.002	.961	.048
	N	81	81	81	81	81	81	81	81	81
Weight	Pearson Correlation	-.671**	.225*	.202	.710**	1	.011	.347**	-.069	.210
	Sig. (2-tailed)	.000	.043	.070	.000		.925	.001	.538	.060
	N	81	81	81	81	81	81	81	81	81
Accel(No) Pump(No): Decel	Pearson Correlation	-.050	-.136	-.133	.020	.011	1	.614**	-.174	.786**
	Sig. (2-tailed)	.655	.228	.237	.857	.925		.000	.120	.000
	N	81	81	81	81	81	81	81	81	81
Accel(No) Pump(No): BrakeMean	Pearson Correlation	-.339**	-.068	-.092	.341**	.347**	.614**	1	-.126	.922**
	Sig. (2-tailed)	.002	.546	.413	.002	.001	.000		.262	.000
	N	81	81	81	81	81	81	81	81	81
Accel(No) Pump(No): VacuumMean	Pearson Correlation	.065	.054	.082	-.006	-.069	-.174	-.126	1	-.177
	Sig. (2-tailed)	.563	.630	.469	.961	.538	.120	.262		.113
	N	81	81	81	81	81	81	81	81	81
Accel(No) Pump(No): MCMean	Pearson Correlation	-.256*	-.101	-.131	.220*	.210	.786**	.922**	-.177	1
	Sig. (2-tailed)	.021	.369	.244	.048	.060	.000	.000	.113	
	N	81	81	81	81	81	81	81	81	81

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Figure 27. Throttle Closed, No Pump.

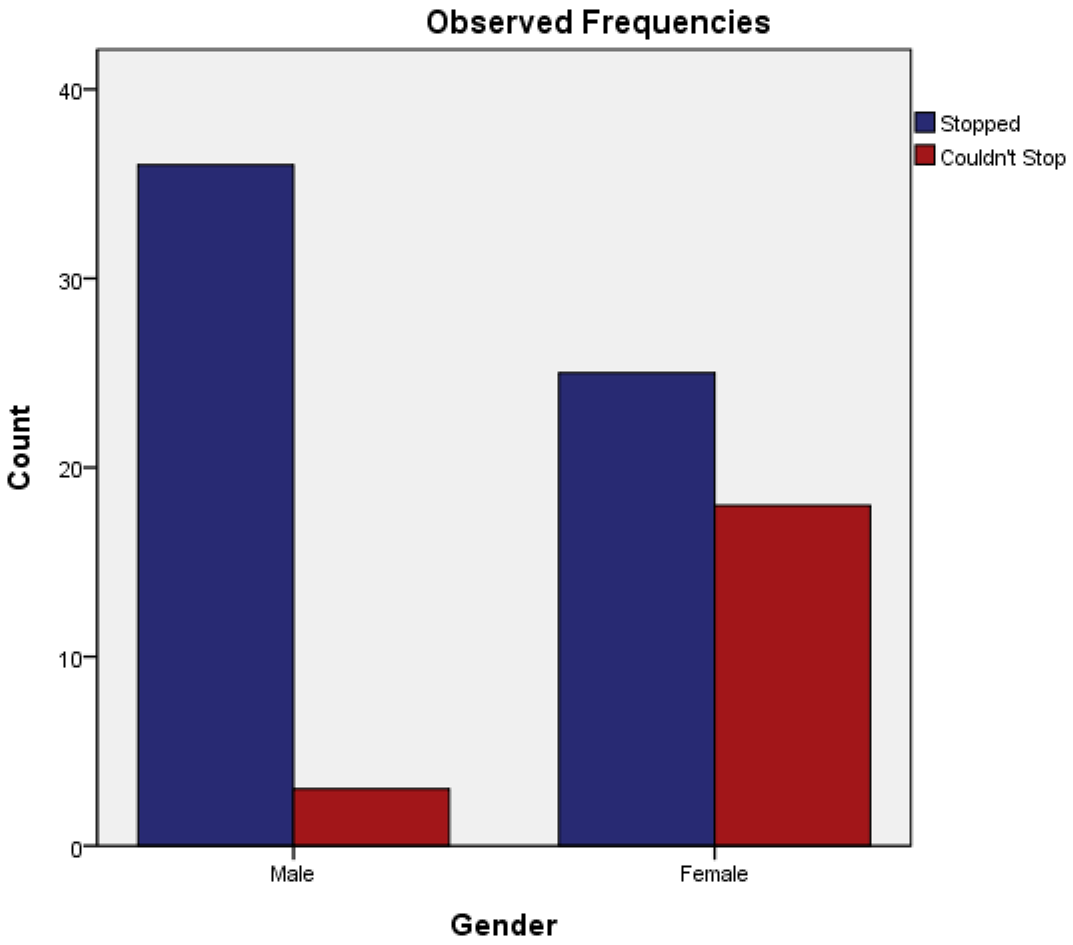


Figure 28. Observed frequencies of ability to stop the accelerating vehicle after the vacuum is depleted

Height.

A One-way ANOVA revealed that participants who were able to stop the accelerating vehicle were on average 2.14 inches taller than those who were unable to bring the vehicle to a stop when the vacuum assist was depleted, *F*(1, 81) = 5.72, *p* = .019.

Table 5 provides descriptive statistics for height, including mean, standard deviation (SD), and standard error of the mean (SE), for those that could and could not stop the vehicle.

Table 5

Height of participants that could and could not stop the vehicle during the Throttle Open, Brake Pump deceleration condition

	Mean (in)	SD	SE
Stopped	68.38	3.81	.49
Couldn’t Stop	66.24	2.55	.56

Weight.

A One-way ANOVA revealed that participants who were able to stop the accelerating vehicle were on average 20.64 lbs heavier than those who were unable to bring the vehicle to a stop when the vacuum assist was depleted, *F*(1, 81) = 5.49, *p* = .022. Table 6 provides weight descriptives, including mean, standard deviation (SD), and standard error of the mean (SE).

Table 6

Weight of Participants That Could and Could Not Stop the Vehicle During the Throttle Open, Brake Pump Deceleration Condition.

	Mean (lbs)	SD	SE
Stopped	168.54	35.90	4.60
Couldn't Stop	147.90	31.30	6.83

Age.

A One-way ANOVA revealed no significant differences between age and ability to stop the accelerating vehicle when the vacuum assist was depleted, *F*(1, 81) = .007, *p* = .932.

Observational Note.

In addition, 2 of the 21 participants who were unable to stop the accelerating vehicle when the vacuum assist was depleted were also unable to stop the accelerating vehicle when the vacuum assist was *not* depleted.

Contrasts between the Four Deceleration Conditions

In order to evaluate the differential effects of gender on key deceleration variables during the four deceleration events, a series of repeated measures Analyses of Variance (ANOVAs) were run. For these analyses we evaluated the result of an Open-throttle, Brake Pumping, and Gender on Mean Deceleration Rate, Mean Brake Pedal Force, Mean Vacuum Pressure, and Mean Main Cylinder Pressure. The results of these analyses are shared in Table 7 -Table 10 and Figure 29 -Figure 32 below. In general, whether the throttle was experimentally opened or not, whether the brakes were pumped or not, and whether the driver was male or female, each significantly impacted the Deceleration Rate, Mean Brake Pedal Force, Mean Vacuum Pressure, and Mean Master Cylinder Pressure. The exception to this was that gender did not affect Vacuum Pressure (this was exactly as expected given the role of the braking vacuum).

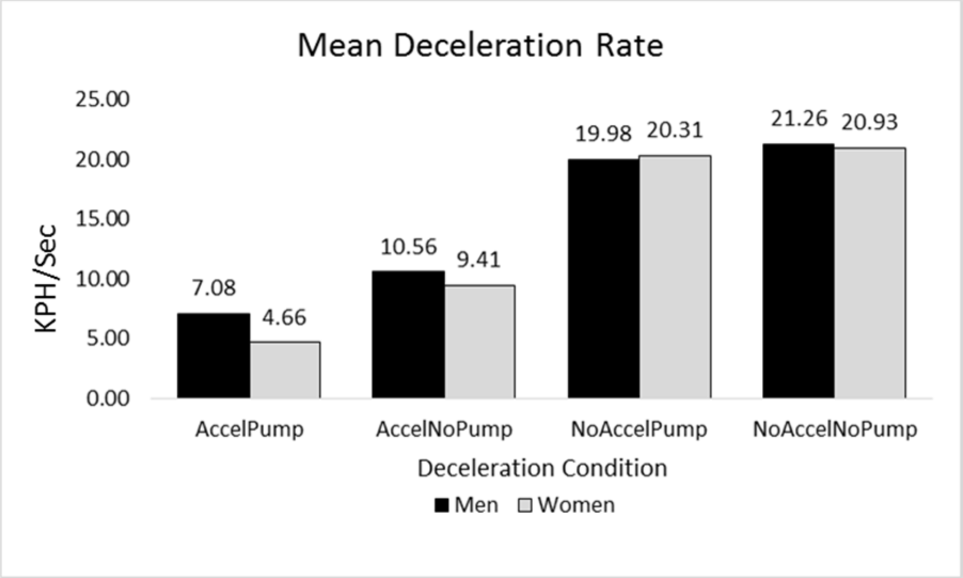


Figure 29. Mean deceleration rate of men compared to women across conditions

Table 7

Deceleration Rate

Source	**d.f.**	**F**	**p**	**Partial Eta Sq.**
Accelerator	**(1, 79)**	**1435**	**.000**	**.948**
Pumping	**(1, 79)**	**75.1**	**.000**	**.487**
Gender	**(1, 79)**	**4.435**	**.038**	**.054**
Accelerator x Pumping	**(1, 79)**	**41.3**	**.000**	**.344**
Accelerator x Gender	**(1, 79)**	**6.64**	**.012**	**.078**
Pumping x Gender	**(1, 79)**	**0.23**	**.663**	**.003**
Accelerator x Pumping x Gender	**(1, 79)**	**3.46**	**.067**	**.042**

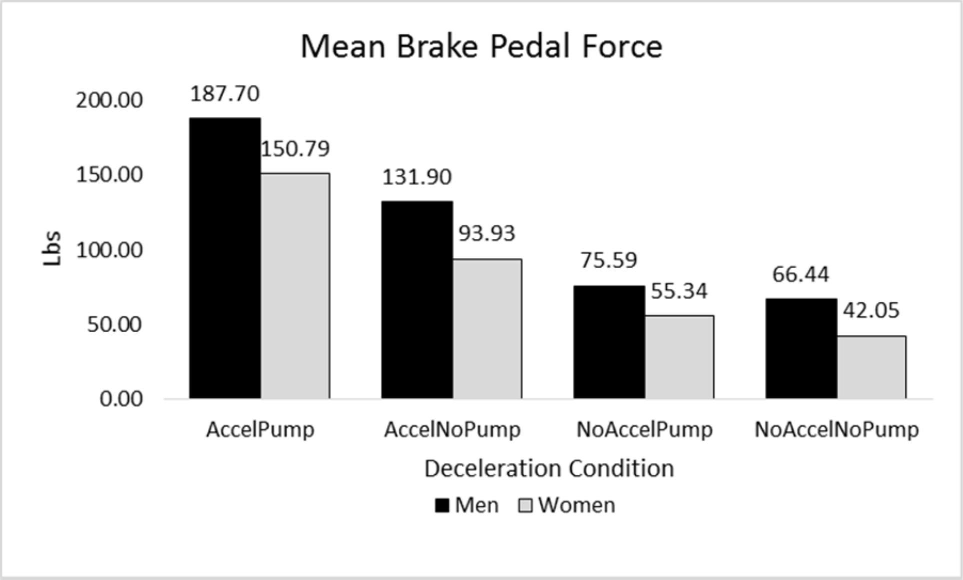


Figure 30. Mean brake pedal force of men compared to women across conditions

Table 8

Mean Brake Force

Source	**d.f.**	**F**	**p**	**Partial Eta Sq.**
Accelerator	**(1, 79)**	**449**	**.000**	**.850**
Pumping	**(1, 79)**	**137**	**.000**	**.636**
Gender	**(1, 79)**	**15.5**	**.000**	**.134**
Accelerator x Pumping	**(1, 79)**	**81.3**	**.000**	**.507**
Accelerator x Gender	**(1, 79)**	**3.49**	**.065**	**.042**
Pumping x Gender	**(1, 79)**	**.269**	**.605**	**.003**
Accelerator x Pumping x Gender	**(1, 79)**	**.089**	**.767**	**.001**

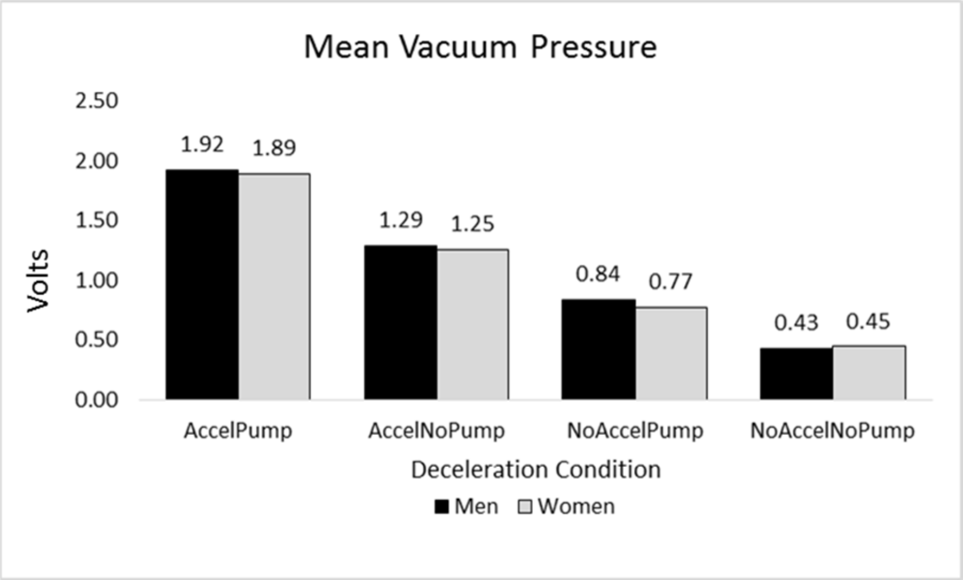


Figure 31. Mean vacuum pressure of men compared to women across conditions

Table 9

Mean Vacuum Pressure

Source	**d.f.**	**F**	**p**	**Partial Eta Sq.**
Accelerator	**(1, 79)**	**4222**	**.000**	**.982**
Pumping	**(1, 79)**	**1013**	**.000**	**.928**
Gender	**(1, 79)**	**1.41**	**.238**	**.018**
Accelerator x Pumping	**(1, 79)**	**63.6**	**.000**	**.446**
Accelerator x Gender	**(1, 79)**	**.157**	**.693**	**.002**
Pumping x Gender	**(1, 79)**	**1.39**	**.241**	**.017**
Accelerator x Pumping x Gender	**(1, 79)**	**1.51**	**.223**	**.019**

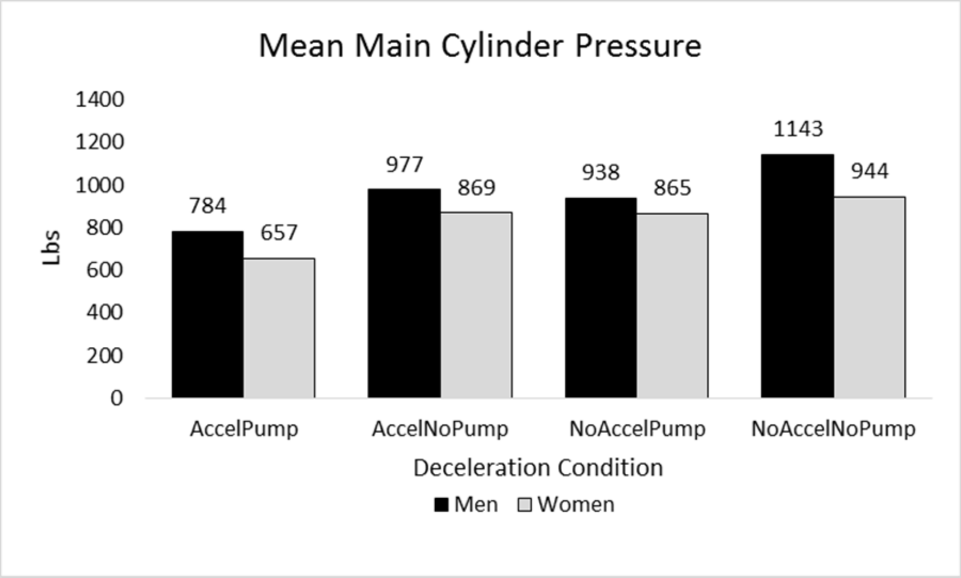


Figure 32. Mean main cylinder pressure of men compared to women across conditions

Table 10

Mean Brake Cylinder Pressure

Source	**d.f.**	**F**	**p**	**Partial Eta Sq.**
Accelerator	**(1, 79)**	**162**	**.000**	**.673**
Pumping	**(1, 79)**	**51.9**	**.000**	**.396**
Gender	**(1, 79)**	**11.1**	**.001**	**.124**
Accelerator x Pumping	**(1, 79)**	**.137**	**.713**	**.002**
Accelerator x Gender	**(1, 79)**	**1.70**	**.196**	**.021**
Pumping x Gender	**(1, 79)**	**.031**	**.860**	**.000**
Accelerator x Pumping x Gender	**(1, 79)**	**2.78**	**.100**	**.034**

Exit Questionnaire

Post-study, participants were asked to fill out a brief exit questionnaire. Participants were asked if they had ever experienced an unintended acceleration (UA) event prior to the day's study: 23 out of the 82 participants (28.0%) reported that they had. Explanations for why their UA occurred ranged from unknown, gas pedal "sticking" (mechanical failures of accelerator), and misapplication of foot to driving mats or objects becoming lodged underfoot.

Participants were asked if they knew anyone who had experienced a UA event: 5 out of the 82 participants (6.1%) reported that they did. Those known were friends and family members who reported similar explanations listed previously.

Participants responded to the following questions on a seven item Likert scale ranging from (1) "Not at All" to (7) "Extremely." Descriptive statistics for the resulting data, including mean, standard deviation (SD), and standard error of the mean (SE), are presented in Table 11.

Table 11

Reactions to the UA event

	Mean	SD	SE
Surprised	5.89	1.51	.17
Anxious	5.07	1.46	.16
Familiarity*	3.12	1.97	.22

*Participants clarified that, in general, they had heard about the Audi and Toyota issues on the news or had experienced the issue themselves.

Figure 33 - Figure 35 report participant responses to the following three post-study questions.

1. How surprised were you by the first sudden acceleration of the vehicle?
2. How anxious did you feel when your vehicle suddenly accelerated?
3. Prior to today's study, how familiar were you with the issue of unintended acceleration?

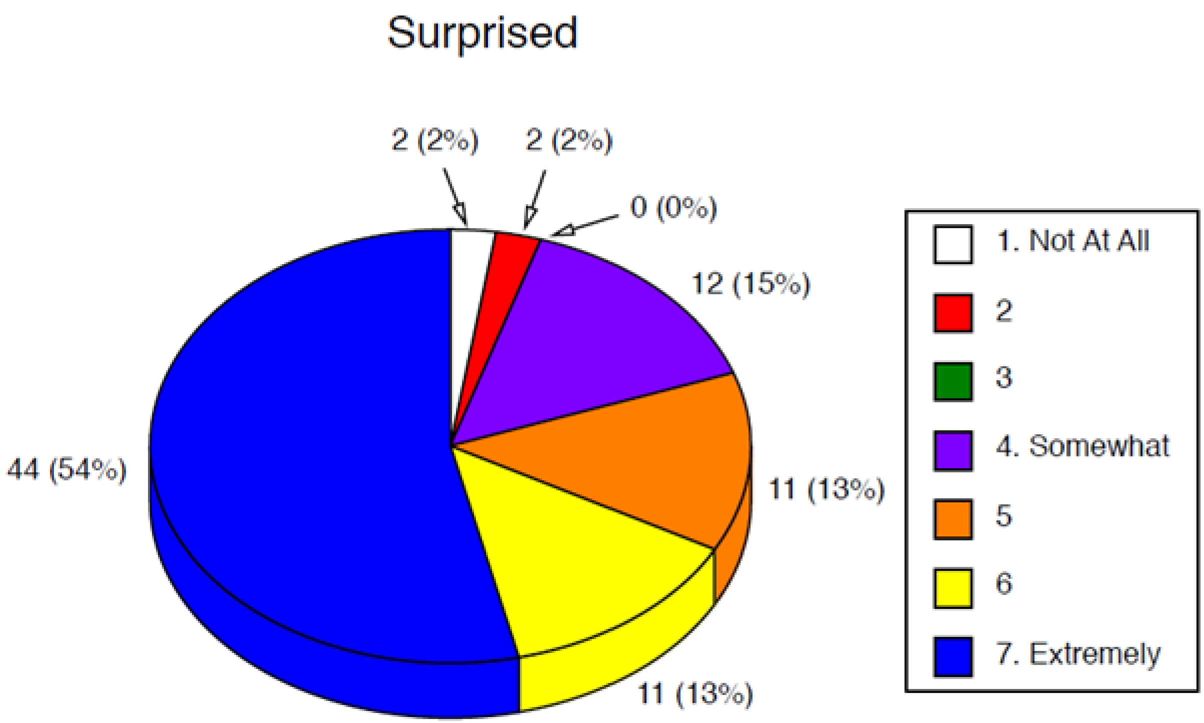


Figure 33. Distribution of responses of how surprised participants were about initial UA event.

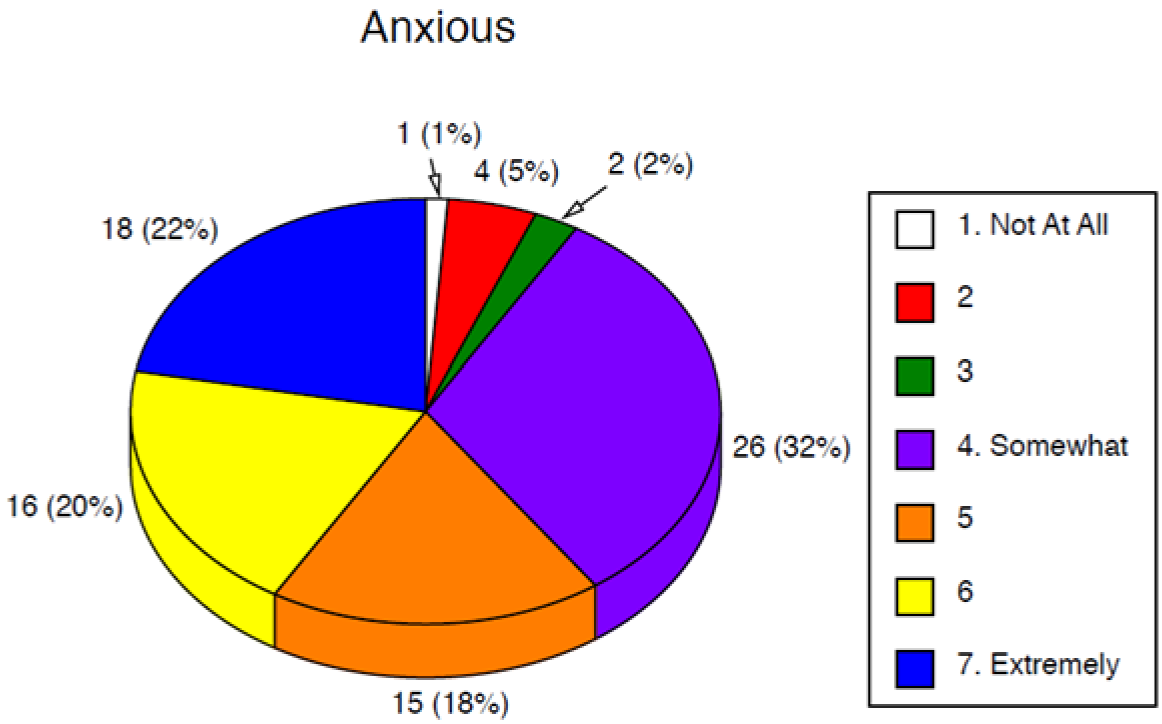


Figure 34. Distribution of responses of how anxious participants were during initial UA event.

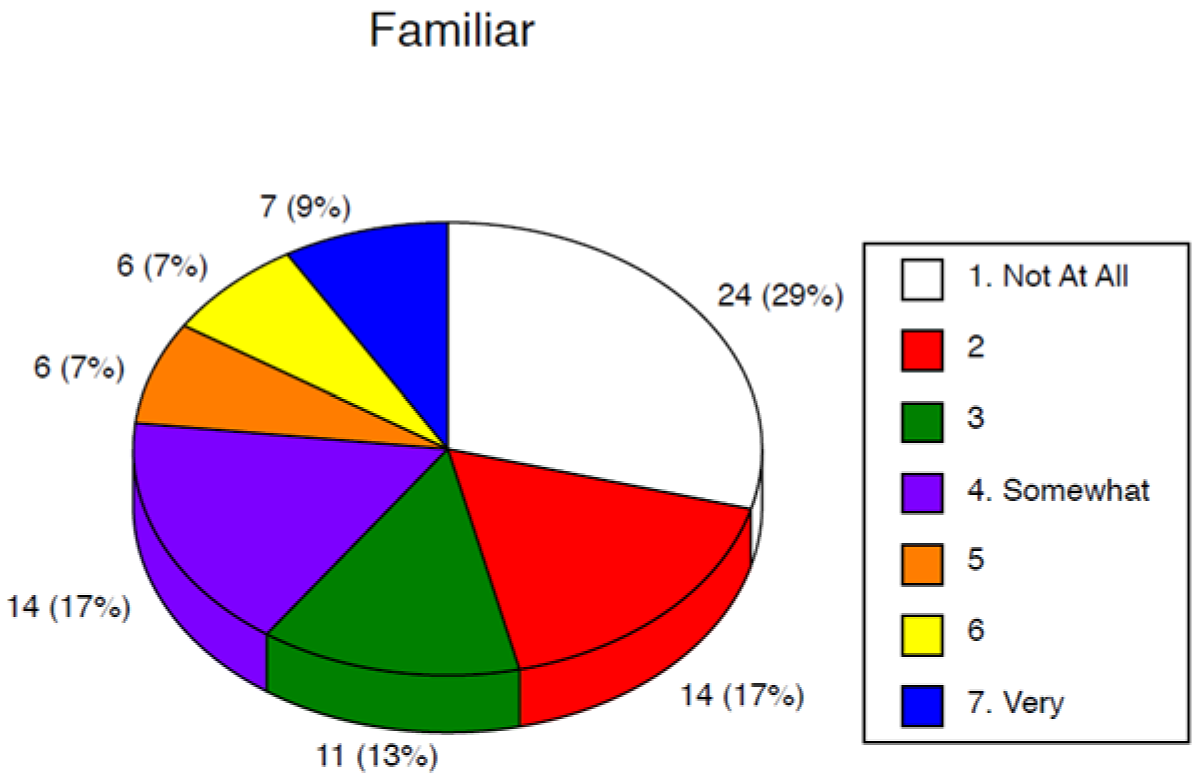


Figure 35. Distribution of responses to how familiar participants were with the issue of UA.

Participants were asked to recall which pedal they pressed in response to the first UA event. Table 12 reports the frequency of responses.

Table 12

Responses to the Question of Which Pedal Participants Pressed After first UA Occurred

	Frequency	Percent
None	2	2.4%
Accelerator	2	2.4%
Brake	78	95.1%
Total Participants	82	100

Participants were also asked if they had any additional comments regarding their experience in the study (see Appendix J for a complete list of participants' comments). In summary, participants indicated their surprise at the UA event, their ignorance of how to properly react (i.e., putting the car in Neutral), reasons why they pumped the brake (i.e., previous training in older vehicles; reacting as if they had hit oil or ice), and surprise at the difficulty of stopping the vehicle especially when the vacuum was depleted by pumping the brake.

Appendix A: IRB approved procedure document

Note: The section which describes the vehicle modifications is actually not correct. These were the anticipated vehicle modifications at the time of IRB application. The actual vehicle that was used in this research did not have a vacuum depletion device as is suggested in this description.

Unintended Acceleration Procedure

High Level Overview

The purpose of this study is to investigate how older adult drivers respond to Unintended Acceleration (UA) events while driving. A UA is defined by Wikipedia as an “unintended, unexpected, uncontrolled acceleration of a vehicle, often accompanied by apparent loss of braking effectiveness”. UA events have recently been observed in a number of high profile cases. The actual cause of a UA event likely differs from case to case but may arise from driver error (e.g., pedal confusion), mechanical or electrical problems, or both. This study will help to disambiguate driver response at the moment a UA event occurs and will provide important information that can be used to help reduce the incidence of UA occurrence.

In order to ensure the safety of our participants all testing of UA events will be conducted at relatively low speeds (35 mph or under) on an expansive closed driving course. In addition, a research confederate will accompany participants in the vehicle at all times and will have access to a variety of vehicle controls to safely intercede if necessary.

To accurately assess a driver’s response at the time of a UA it is critical that drivers are unaware that a UA event will occur. Thus, test subjects will, by necessity, be unaware of the exact purposes of this research until after the evaluation is completed.

Participants

Sixty Orange County residents will participate in this study. Half will be males and half will be females. All will be between the ages of 55 and 75.

Recruitment

Participants will be recruited from advertisements placed in the newspaper, online, or through word of mouth. In order to participate in this research, interested persons will be required to meet strict screening criteria (See telephone screening document).

Research Vehicle

A 2005 Toyota Camry will be used as the research vehicle. Prior to use in this experiment, the vehicle will undergo a complete safety inspection to ensure that it is in good working order and that all of its active safety systems are functional. In addition, a daily safety inspection will be performed to ensure that the vehicle remains in good working order throughout the duration of the experiment. This safety inspection will take especially focus on brake pad and/or rotor wear. If any unusual wear is detected, worn part will be replaced prior to additional use of the vehicle.

Vehicle Instrumentation

The vehicle features instrumentation on the steering, brake, and gas pedals to collect driver control inputs. These are non-invasive sensors that do not affect the normal operation of the vehicle. A set of small cameras is also placed in the vehicle. The placement of these cameras will not impede the driving environment or block any access to critical vehicle controls. At least one camera will be positioned to capture a view of the participants face and one camera will be positioned to capture a view of the participant's feet and the vehicle pedals.

Vehicle Modifications for Experiment

The vehicle features two special modifications to the acceleration and braking systems. The throttle control body features a controllable fault which can be remotely controlled and causes the vehicle throttle body to fully open (i.e., apply "full throttle"). The fault can also be remotely, and instantaneously, reset to reinstate normal throttle operation. In this way, the experimenter can, through a remote control, cause the vehicle to accelerate at full throttle and also reinstate full throttle control to the participant.

The vehicle braking system also features a special modification which can remotely deplete the "Vacuum Assist" of the brakes. Vacuum Assist is a feature in most modern cars which boosts brake inputs by the driver. The purpose of Vacuum Assist is to make it possible for drivers to achieve maximal deceleration with a reduced effort. Under normal conditions, the boost from Vacuum Assist can be cleared by repeatedly pumping the brakes, especially if the engine is off or the RPM's of the engine are high. Vacuum Assist is not, however, needed to apply full braking force and brakes are still fully functional without Vacuum Assist. However, additional pedal force is required to achieve the same rate of deceleration when Vacuum Assist is depleted.

Additional Vehicle Safety Features

A vehicle kill switch is wired into the car which can immediately disable all throttle inputs to the engine. This is a backup safety feature that will not be used under normal operation but can be used to in the event of an unusual circumstance. This button is controllable by the research participant.

To ensure the safety of all research participants, a passenger side brake is installed in the vehicle. As with the driver side brake, this brake has the power to bring the vehicle to a rapid and complete stop, even if the engine is simultaneously trying to speed the vehicle (such as when the throttle body is open). Like the driver side brake, experimental depletion of the Vacuum Assist does not result in a loss of braking power, but does require that additional brake force be applied in order to attain the same rate of deceleration.

Test Track

Testing will take place at the Orange County Great Park. This park is a decommissioned Marine base featuring an extensive network of airplane runways and taxiways. Within this facility, a 1.5 mile, straight runway will be used for the UA event. The entire 1.5 mile runway will be closed off and secured for testing and no other vehicles will be present.

Procedure

During data collection, participants will be seated in the driver seat and a research assistant will be seated in the passenger seat. Participants will be informed that the purpose of the study is to evaluate vehicle control behaviors. Participants will not be aware that a sudden Unintended Acceleration (UA) event will occur during the drive. The researcher seated in the passenger seat will instruct participants as to the desired road course.

The experiment will begin at the south end of the Eastern runway with a North-South orientation See Figure X. From there, participants will drive North down the runway, turning onto the right onto the eastern taxiway road at the end of the runway. They will then make a loop clockwise around the facility until they return to their original starting position. Participants will be instructed to drive either 35 or 50 mph on the runway, depending on the experimental condition, and no faster than 25 mph on the taxiways. After returning back to the southern tip of the main runway, the UA event will begin.

The Unintended Acceleration Event

The research design will be a 4 level, mixed between and within-subject design. The within subject factor will be braking under normal conditions (No UA event, full Vacuum Assist). The between subject conditions will be:

1. UA event at 35 mph with foot lightly resting on the accelerator
2. UA event at 35 mph with foot resting on the brake
3. UA event during parking.

Each participant shall experience only one UA scenario;:

1. UA event at 35 mph with foot lightly resting on accelerator – Participants shall be instructed to maintain a speed of approximately 35 mph. The UA will be triggered while the Participant is not applying the brakes.
2. UA event at 35 mph with foot lightly resting on the brake – Participants shall be instructed to bring the vehicle to a speed of approximately 50 mph, and then apply the brakes to smoothly slow the car to about 30 mph. The UA will be triggered when the vehicle speed reaches approximately 40 mph and the brakes are being applied.
3. UA event during parking – Participants will be instructed to either park “head-in” or to parallel park. The parking space will be defined with traffic cones. The UA will be triggered during the parking maneuver, preferable while the brakes are being applied.

The UA event will be generated electronically by via a remote switch that is activated by the experimenter. The event will be triggered at a predefined location on the runway approximately .25 miles to the North of the Southern end. This will leave approximately 1.25 miles of open roadway in front of the participant vehicle. The UA event will be terminated by the experimenter if any of the following occurs:

1. Vehicle speeds rise above 65 mph.
2. The vehicle travels further than .5 miles.
3. The participant asks for guidance on how to slow the vehicle.
4. The participant exhibits moderate distress that lasts longer than a 5 seconds.
5. The participant exhibits severe distress.
6. The experimenter has any reason to believe that the safety of the participant may be in jeopardy.
7. The participant requests to end the study.

Experimenter Role During Testing

The primary role of the experimenter is to ensure the safety of participants. The experimenter will also provide navigational instructions to the participant. They will do this by serving as an extra set of eyes for the participant during the entire study and alerting the participant of any potential risks in the driving environment

Final Questionnaire and Debriefing

When any of the above criteria for terminating the UA event are met, the experimenter will depress the passenger side brake and bring the vehicle to a complete stop. Once the vehicle is placed into park the experimenter will ask the participant a set of questions relating to the UA event that they just experienced (See Exit Questionnaire document). Following this, participants will then be verbally debriefed about the true purpose of the experiment (See Debriefing Form) and be instructed to return the vehicle to the intake area at the south end of the main runway. Participants will then be thanked for their participation and paid for their time.

Appendix B: Screening Requirements

Thank you for calling about a research study we will be doing. The purpose of the study is to evaluate natural driver behavior relating to vehicle dynamics and control. Participation in this study will last about 40 minutes. It involves driving an instrumented vehicle that will record information about the vehicle systems as well as video images of the roadway and driver. [Will take place at El Toro Airfield in Orange County Great Park]. You will be compensated with $50 for your time.

To see if you qualify for this study, I need to ask you some questions about your health history and driving experience. Some of these questions may be sensitive, such as questions about drug use and personal health. You do not have to respond to any question; however, you will not be eligible to participate in the study if you choose not to answer. You may stop this interview at any time for any reason and we will not contact you further. If you do not qualify for this study, the information you give me will be destroyed immediately. Do I have your permission to proceed?

1 What is your date of birth?

VERIFY THAT DATE OF BIRTH MEETS AGE QUALIFICATIONS

2 Are you available for one hour on <insert date> to participate in the study located at <insert location>?

IF RESPONSE IS NO, THANK AND END

3 Do you currently hold a valid driver's license?

IF RESPONSE IS NO, THANK AND END

4 How long have you held a driver's license?

5 Are you able to drive an automatic transmission (not a stick shift) without assistive devices or special equipment?

IF RESPONSE IS NO, THANK AND END

6 How would you rate your overall physical health?

IF ANYTHING OTHER THAN "GOOD" OR EQUIVALENT, THANK AND END

7 Do you have a history of any of the following medical conditions? Please respond yes or no.

READ LIST AND CHECK RESPONSE. THANK AND END IF RESPOND "YES" TO ANY CONDITION.

MEDICAL CONDITION	**NO**	**YES**

Any type of heart condition		
Stroke		
Brain tumor		
Head injury		
Brain damage		
Neck or back pain or injury		
Epileptic seizures or lapses of consciousness		
Respiratory disorders (e.g., COPD, lung cancer, acute bronchitis, etc.)		
Motion sickness		
Inner ear problems		
Dizziness, vertigo or other balance problems		
Eye injury or eye surgery		
Diabetes (Type I or II)		
Migraines or tension headaches		
Have you had major surgery in the past 6 months?		
Do you have any history of post-traumatic stress disorder		
Osteoporosis		

8 (ASK FEMALES ONLY) Are you pregnant?

- Yes (POLITELY INFORM RESPONDENT THAT DUE TO THE NATURE OF THIS PARTICULAR STUDY, WE ARE NOT ABLE TO ALLOW PREGNANT WOMEN TO PARTICIPATE. THANK AND END)
- No (CONTINUE)

9 Are you currently taking any substances or medications on a regular basis that would impact your ability to drive (e.g., causes drowsiness or dizziness)?

- Yes (THANK AND END)
- No (CONTINUE)

10 Do you have normal, or corrected to normal, hearing and vision?

- Yes (CONTINUE)
- No (THANK AND END)

11 Do you or any members of your household work for any of the following fields or types of companies: IF YES TO ANY, THANK AND END

- Design, engineering, or development of automotive-related technologies?
- A manufacturer, distributor or retailer of automotive parts
- An auto mechanic / technician / auto repair shop
- Have you ever been a professional driver of any kind, such as a taxi driver, test driver, school bus driver, delivery driver, limousine driver, or truck driver?
- Have you ever been involved in any type of driver racing activity?
- Have you ever attended a professional driving school of any kind?
- Do you or any member of your direct family currently work for an automobile dealer?
- Do you or any member of your direct family currently work for a law firm representing or adverse to any automobile or automobile parts manufacturer?

12 Finally, your participation in this driving study will include having to do some reading, writing, and survey-taking. Are you comfortable completing all of these tasks IN ENGLISH?

- Yes (CONTINUE)
- No (THANK AND END)

13 ENGAGE THE RESPONDENT IN CONVERSATION TO VERIFY THEIR ABILITY TO CONVERSE FLUENTLY IN ENGLISH – ESPECIALLY IMPORTANT FOR FOCUS GROUP PARTICIPANTS.

Thank you for answering these questions. You meet the requirements for this study and if you would like we could set up a time for participation. We currently have [state date and times] available. Is there one of these times that might work best for you?
Perfect, I have you down for the [state date] at [state time]. We will give you a call the day before your appointment to remind you. [Get phone number, email]. Do you have any additional questions for use? Thanks again and we will see you [state date] at [state time]. Goodbye.
++
Thank you for answering these questions. Unfortunately, you do not meet the requirements for this study. The answers you provided to these phone questions will be destroyed and no further record of this conversation will be maintained. Thank you again for your time. If you know anybody else that might be interested in participating in this research, please have them contact us.
++

Appendix C: Pre-Study Participant Information Packets

CONFIDENTIALITY AGREEMENT

I hereby agree to keep confidential, and to not discuss, my involvement in today's research project at El Toro Field for a period of six (6) months from today's date.

I will not disclose any details or information about this research project to anyone for a period of six (6) months from today's date.[1]

Dated: May ____, 2013 ____

Signature of Participant

---

[1] This Confidentiality Agreement does not prevent disclosure of information in the unlikely event that it is compelled by law

EXPERIMENTAL SUBJECT'S BILL OF RIGHTS

California law, under Health & Safety Code Section 24172, requires that anyone who is asked to be in a research study (medical experiment), or who is asked to agree for someone else to be in a research study, has the right to know the following, in a language in which the person is fluent:

- Both the nature and reason for the research study or experiment.
- What will happen during the research study, and what drug or device will be used.
- Any expected discomforts and risks from taking part in the research.
- Any possible benefits to being in the research.
- The risks and benefits of any non-experimental medical procedures, drugs, or devices that could be used instead of being in the research.
- How research related complications will be treated during and after the research study is over.
- Questions can be asked about the research and about anything that will be done during the research study.
- The research subject can stop taking part in the research study at any time for any reason without penalty or loss of benefits.
- A copy of their signed and dated consent form will be given to subjects.
- The research subject can take the time needed to decide if they want to take part in the research study. No one can pressure, force or unduly influence any person to take part in research.

____________________________________ __________________________

Signature of Subject Date

APPROVED
Apr 23, 2013
WIRB®

Research Subject Information and Consent Form

TITLE:	Evaluation of Vehicle Control Dynamics using a Secure Driving Test Track
PROTOCOL NO.:	None WIRB® Protocol #20130585
SPONSOR:	Applied Cognitive Sciences
INVESTIGATOR:	Joel Cooper, Ph.D. 936 S 1500 E Salt Lake City, Utah 84105 United States
SITE(S):	Orange County Great Park 6990 Marine Way Irvine, California 92618 United States
STUDY-RELATED PHONE NUMBER(S):	Joel Cooper, Ph.D. 801-520-5408 (24 hours) Zac Doerzaph, Ph.D. 540-239-4237 (24 hours)
SUB-INVESTIGATOR(S):	Zac Doerzaph, Ph.D.
STUDY-COORDINATOR(S):	Rick Gill, Ph.D.

APPROVED
Apr 23, 2013
WIRB®

SUMMARY

You are being asked to be in a research study. The purpose of this consent form is to help you decide if you want to be in the research study.

If you have health concerns that may affect your ability to safely drive a motor vehicle please discuss these with the researcher.

You should not join this research study until all of your questions are answered.

If you take part in this research study, you will be given a copy of this signed and dated consent form.

PURPOSE OF THE STUDY

This research is being conducted to better understand the throttle, gas, and steering inputs of healthy adult drivers. This research consists of a brief intake survey followed by a single driving observation that will last approximately 20 minutes. During this driving observation, you will be accompanied by a staff researcher at all times. And your interactions with the vehicle, including video, will be recorded for later analysis. After you drive, we will ask that you fill out a brief exit questionnaire. The entire study should last no more than 40 minutes from start to finish.

About 60 people will take part in this study.

PROCEDURES

- Complete intake paperwork
    - Sign and date the consent form (this form)
    - Complete driving survey
- Drive around the California Great Park in our research vehicle
- Complete exit paperwork
    - Fill out Exit Survey
    - Receive a study debriefing

RISKS AND DISCOMFORTS

Potential risks from participating in this research are similar to those encountered in everyday driving. Similar to everyday driving, there may be other vehicles on the road and you must drive and react as you normally would when you interact with these vehicles. You will have physical control of the vehicle at all times and will be responsible for insuring it is operated safely. The study procedure has been designed to minimize the risk from your surroundings including other motor vehicles. All steps have been taken to ensure your safety in the event of an accident. If at any time you feel uncomfortable or unsafe performing any of the tasks asked of you, you have the right to refuse to perform the task, with no effect on the compensation for your participation in this research study.

A cellular telephone will be available to the researcher at all times. In case of an accident or medical emergency, appropriate emergency medical services will be called. However, neither Precision Driving Research nor any other sponsors of this project will assume financial responsibility for any medical costs incurred due to your participation in this study. Continuing medical care and/or hospitalization for research-related injury will not be provided free of charge nor will financial compensation be available or provided by the investigators. Participants are encouraged to review their medical insurance coverage to ensure it is adequate.

BENEFITS

There are no direct benefits. The societal benefits are that this study will provide information concerning vehicle control and driver behavior. This information may also be of use for public policy makers dealing with traffic safety issues.

PAYMENT FOR PARTICIPATION

You will be paid $50 for completing this study. If you do not complete the study, you will be still be paid $50 for your participation.

ALTERNATIVE TREATMENT

This is not a treatment study. Your alternative is not to be in this study.

CONFIDENTIALITY

Information from this study will be given to the sponsor. “Sponsor” includes any persons or companies that are contracted by the sponsor to have access to the research information during and after the study. Your records may be provided to the Western Institutional Review Board (WIRB®)

The results of this research study may be presented at meetings or in publications. Your identity will not be disclosed in those presentations.

COMPENSATION FOR INJURY

If you are injured or get sick as a result of being in this study, your insurance will be billed for this treatment. No other payment is routinely available from the study doctor or sponsor.

VOLUNTARY PARTICIPATION AND WITHDRAWAL

Your participation in this study is voluntary. You may decide not to participate or you may leave the study at any time. Your decision will not result in any penalty or loss of benefits to which you are entitled.

Your participation in this study may be stopped at any time by the study sponsor without your consent for any reason, including:

- if it is in your best interest;
- you do not consent to continue in the study after being told of changes in the research that may affect you;

SOURCE OF FUNDING FOR THE STUDY

The sponsor Precision Driving Research will pay for this research study.

QUESTIONS

Contact Joel Cooper at 801-520-5408 (24 hours) for any of the following reasons:

- if you have any questions about your participation in this study,
- if you have questions, concerns or complaints about the research

Contact Zac Doerzaph at 540-239-4237 (24 hours) if you feel you have had a research related injury.

If you have questions about your rights as a research subject or if you have questions, concerns or complaints about the research, you may contact:
Western Institutional Review Board® (WIRB®)

3535 Seventh Avenue, SW
Olympia, Washington 98502
Telephone: 1-800-562-4789 or 360-252-2500
E-mail: Help@wirb.com

WIRB is a group of people who independently review research.

WIRB will not be able to answer some study-specific questions, such as questions about appointment times. However, you may contact WIRB if the research staff cannot be reached or if you wish to talk to someone other than the research staff.

Do not sign this consent form unless you have had a chance to ask questions and have gotten satisfactory answers.

If you agree to be in this study, you will receive a signed and dated copy of this consent form for your records.

CONSENT
I have read this consent form. All my questions about the study and my part in it have been answered. I freely consent to be in this research study.

By signing this consent form, I have not given up any of my legal rights.

____
Subject Name (printed)

____ ___________________
Signature of Subject Date

Appendix D: Post-Study Participant Information Packet

Exit Questionnaire

Subject ID ___________ Experimental Condition ____________

Answer the following three questions on a scale of 1 to 7.

1	2	3	4	5	6	7
Not at All			Somewhat			Extremely

1 ____ How surprised were you by the first sudden acceleration of the vehicle?
2 ____ How anxious did you feel when your vehicle suddenly accelerated?
3 ____ Prior to today's study, how familiar were you with the issue of unintended acceleration?

Have you ever experienced an unintended acceleration before today? If yes, please elaborate.
____
____
____
____
____

Do you know anyone that has experienced an unintended acceleration event? If yes, please elaborate.
____
____
____
____
____

Which pedal did you press when your vehicle suddenly accelerated for the first time in today's study?
____

What additional comments do you have for us about your experience in today's study?
____
____
____
____

WIRB 20130585
#10854246.0

Debriefing Form

Thank you for participating in this study. As you are now aware, the true purpose of this study was to see how people respond to unanticipated vehicle accelerations. If you had known about the real purpose of this research your behavior may have been very different. Therefore, in order for us to observe the most natural response possible it was necessary to keep that portion of the research a secret, until after the study.

During the unanticipated acceleration event your safety was our first priority. Although you may have felt that the vehicle behaved in ways that were outside of your control, it was always in the control of the researcher seated in the passenger seat. To ensure your safety, the vehicle that you drove had a number of extra safety devices, including a button to immediately cut off the throttle and a redundant passenger side brake that was always operational.

Now that we have recorded your driving behavior during an unanticipated event, we will go back and look at the video and the data from the brake and gas pedals. The way in which you, and others, respond will help us to better understand the types of response that people make during these events. This data may be used in legal cases or presented at scientific conferences related to driver behavior and may hopefully be used to reduce serious accidents or fatalities that are associated with these types of events.
Do you have any questions for us?

Thank you again.

Appendix E: Facilitator Instructions V.3

Training

- Accelerate up to 35 mph and then gradually come to a stop
- Accelerate up to 35 mph and then quickly come to a stop
- Accelerate up to 35 mph and then come to an emergency stop
- Accelerate up to 35 mph until you reach the traffic cones
- Carefully weave through the orange cones making sure not to hit any of them, do not exceed 10 mph.
- Practice making turns around the cones at end of runway

Constant

- (From a stop) Please gradually accelerate up to 20 mph and maintain that speed until you begin slowing to avoid the cone wall.
- Please bring your vehicle to a complete stop at least two vehicle lengths before the cone wall
- (If participants seek guidance) This is part of the test, please do your best to bring your car to a complete stop.

(1) AyVy: Please gradually accelerate the car to 30 mph. At some point during your acceleration I will cause the vehicle to rapidly accelerate. When this happens, please bring your vehicle to a complete stop as quickly as you are able.

(2) AnVn: Please gradually accelerate the car to 30 mph, when I say “Pump the brakes” please rapidly pump the brakes 4 times and count the pumps out-loud. After the fourth pump, please bring the car to a stop as quickly as you are able.

(3) AnVy: Please gradually accelerate the car to 30 mph. When I say STOP, please bring the car to a complete stop as quickly as you are able

(4) AyVn: Please gradually accelerate the car to 30 mph. At some point during your acceleration I will cause the vehicle to rapidly accelerate. I will then say “Pump the brakes”. When I do, please rapidly pump the brakes 4 times and count the pumps out-loud. After the fourth pump, please bring the car to a stop as quickly as you are able.

Appendix F: Run Sheet

Table F13

Participant Run Order

1	Decel	(1) AyVy	(2) AnVn	(3) AnVy	(4) AyVn
2	Accel				
3	Decel	AnVn	AyVy	AnVy	AyVn
4	Accel				
5	Decel	AnVy	AnVn	AyVy	AyVn
6	Accel				
7	Decel	AnVy	AnVn	AyVy	AyVn
8	Accel				
9	Decel	AyVy	AnVy	AnVn	AyVn
10	Accel				
11	Decel	AnVn	AyVy	AnVy	AyVn
12	Accel				
13	Decel	AnVy	AnVn	AyVy	AyVn
14	Accel				
15	Decel	AnVy	AnVn	AyVy	AyVn
16	Accel				
17	Decel	AyVy	AnVy	AnVn	AyVn
18	Accel				
19	Decel	AnVn	AyVy	AnVy	AyVn
20	Accel				
21	Decel	AnVy	AnVn	AyVy	AyVn
22	Accel				
23	Decel	AnVy	AnVn	AyVy	AyVn
24	Constant				
25	Constant	AyVy	AnVy	AnVn	AyVn
26	Constant				
27	Constant	AnVn	AyVy	AnVy	AyVn
28	Constant				

29	Constant	AnVy	AnVn	AyVy	AyVn
30	Constant				
31	Constant	AnVy	AnVn	AyVy	AyVn
32	Constant				
33	Constant	AyVy	AnVy	AnVn	AyVn
34	Constant				
35	Constant	AnVn	AyVy	AnVy	AyVn
36	Constant				
37	Constant	AnVy	AnVn	AyVy	AyVn
38	Constant				
39	Constant	AnVy	AnVn	AyVy	AyVn
40	Constant				
41	Constant	AyVy	AnVy	AnVn	AyVn
42	Constant				
43	Constant	AnVn	AyVy	AnVy	AyVn
44	Constant				
45	Constant	AnVy	AnVn	AyVy	AyVn
46	Constant				
47	Constant	AnVy	AnVn	AyVy	AyVn
48	Constant				
49	Constant	AyVy	AnVy	AnVn	AyVn
50	Constant				
51	Constant	AnVn	AyVy	AnVy	AyVn
52	Constant				
53	Constant	AnVy	AnVn	AyVy	AyVn
54	Constant				
55	Constant	1	2	3	4
56	Constant	2	3	1	4
57	Constant	3	1	2	4
58	Constant	1	2	3	4
59	Constant	2	3	1	4
60	Constant	3	1	2	4
61	Constant	1	2	3	4

62	Constant	2	3	1	4
63	Constant	3	1	2	4
64	Constant	1	2	3	4
65	Constant	2	3	1	4
66	Constant	3	1	2	4
67	Constant	1	2	3	4
68	Constant	2	3	1	4
69	Constant	3	1	2	4
70	Constant	1	2	3	4
71	Constant	2	3	1	4
72	Constant	3	1	2	4
73	Constant	1	2	3	4
74	Constant	2	3	1	4
75	Constant	3	1	2	4
76	Constant	1	2	3	4
77	Constant	2	3	1	4
78	Constant	3	1	2	4
79	Constant	1	2	3	4
80	Constant	2	3	1	4
81	Constant	3	1	2	4
82	Constant	1	2	3	4
83	Constant	2	3	1	4

Appendix G: Study Advertisements and Recruitment

OC Craigslist Advertisement

Link: http://orangecounty.craigslist.org/evg/3791245890.html
Category: Gigs → Events
Title: Participants Needed for Driving Research (35-75 yrs)
Location: El Toro Airfield, OC Great Park, Irvine
Content: Research Participants Needed for a Driving Study!

UPDATE: We've just expanded our eligible age range! We have many appointment spots remaining, especially on Wednesday the 22nd.

Eligible participants must:
-Be between 35 -75 years old
-Be in good health
-Have a valid California driver's license
-NOT be a professional driver

If interested, please call (XXX) XXX-XXXX or (XXX) XXX-XXXX, or email ElToroDriving @ gmail. com for further details and additional eligibility criteria.
Calls are accepted between 8am and 7pm Pacific time.

Participants will be compensated $50 for their time. The study will last approximately 40 minutes and takes place on a closed driving course at OC Great Park.

The study is taking place on May 20, 21, and 22 (Mon-Wed)

Pay: $50 for 40 minutes of research participation

OC Craigslist Advertisement

Link: http://orangecounty.craigslist.org/etc/3811583780.html
Category: Jobs → Etc.
Title: Participants Needed for PAID Driving Study (35-75 yrs)
Location: El Toro Airstrip, OC Great Park, Irvine
Content:
Research Participants Needed for a Driving Study!

UPDATE: We've just expanded our eligible age range! We have many appointment spots remaining, especially on Wednesday the 22nd.

Eligible participants must:
-Be between 35 -75 years old
-Be in good health
-Have a valid California driver's license
-NOT be a professional driver

If interested, please call (XXX) XXX-XXXX or (XXX) XXX-XXXX, or email ElToroDriving @ gmail. com for further details and additional eligibility criteria.

Calls are accepted between 8am and 7pm Pacific time, 7 days a week.

Participants will be compensated $50 for their time. The study will last approximately 40 minutes and takes place on a closed driving course at OC Great Park.

The study is taking place on May 20, 21, and 22 (Mon-Wed) . We are continuing to take calls/schedule until mid-morning on the 22nd.

LA Daily Online Ad

Participants compensated **$50**.
Eligible participants must:

- Be between **35 – 75 years old**
- Be in good health
- Have a valid California driver's license
- Not be a professional driver

If interested, please call (XXX) XXX-XXXX or (XXX) XXX-XXXX, or email **ElToroDriving@gmail.com** for further details and additional eligibility criteria.
Calls accepted between 8am and 7pm Pacific time.
Study lasts approximately 40 minutes and takes place on a closed driving course.
Study takes place on **May 20, 21**, and **22** (Mon-Wed)
Pay: **$50** for 40 minutes of research participation

OC Register Classified Ad

Research Participants Needed for Driving Study!

Participants compensated **$50**.
Eligible participants must:

- Be between **35 – 75 years old**
- Be in good health
- Have a valid California driver's license
- Not be a professional driver

If interested, please call (XXX) XXX-XXXX or (XXX) XXX-XXXX, or email **ElToroDriving@gmail.com** for further details and additional eligibility criteria.
Calls accepted between 8am and 7pm Pacific time.
Study lasts approximately 40 minutes and takes place on a closed driving course.
Study takes place on **May 20, 21**, and **22** (Mon-Wed)
Pay: **$50** for 40 minutes of research participation

EbayClassifieds.com for Orange County

Link: http://orangecounty.ebayclassifieds.com/everything-else/irvine/participants-wanted-for-paid-driving-study/?ad=27823505
Category: Job → Other → Freelance
Title: Participants wanted for Paid Driving Study
Content same as craigslist

PennySaver.com (online) for Orange County

Password: PrecisionDriving
Link: http://www.pennysaverusa.com/classifieds/event-tickets/tickets/usa/california/orange/irvine/92618/participants-wanted-for-paid-driving-research-69046307.html
Category: Event Tickets (?) → Individual Offers / Events
Title: Participants wanted for Paid Driving Study (35-75 yrs old)
Content: same as craigslist

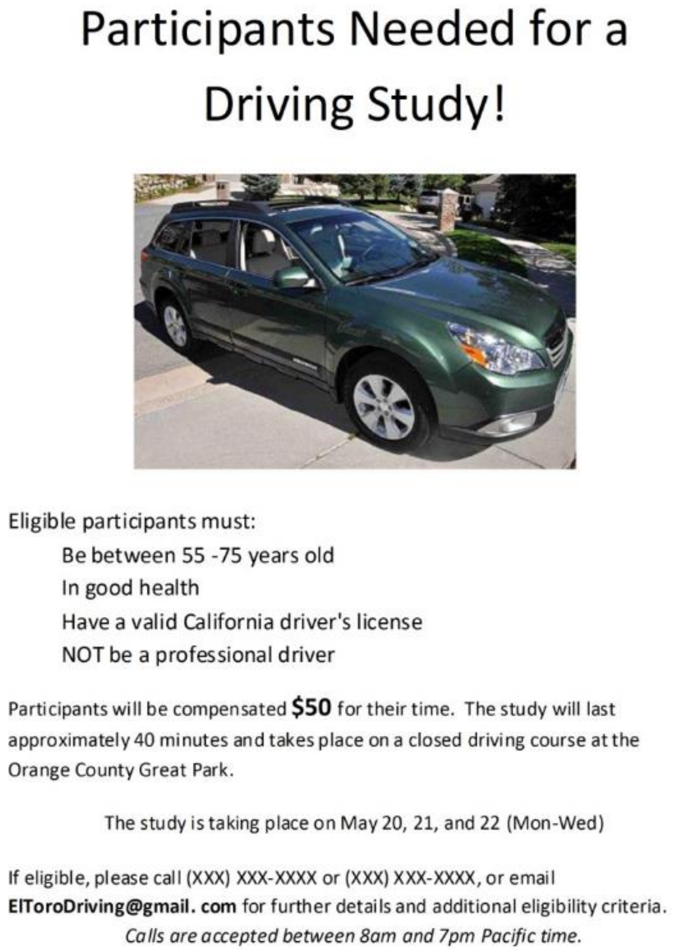
ClassifiedAds.com for Orange County

Link: http://www.classifiedads.com/other_jobs_jobs-ad30985709.htm
Category: Jobs → Other
Title: Participants wanted for Paid Driving Study (35-75 yrs old)
Content: same as craigslist

OrangeCountySuperAds.com

Password: PrecisionDriving
Link:
http://www.orangecountysuperads.com/education_Classifieds/C257A1617658P1/Participants_wanted_for_Paid_Driving_Research.aspx
Category: Jobs → Education (no other even close to relevant category)
Title: Participants wanted for Paid Driving Study (35-75 yrs old)
Content: same as craigslist

Community Flyer



Participants Needed for a Driving Study!

Eligible participants must:

- Be between 55 -75 years old
- In good health
- Have a valid California driver's license
- NOT be a professional driver

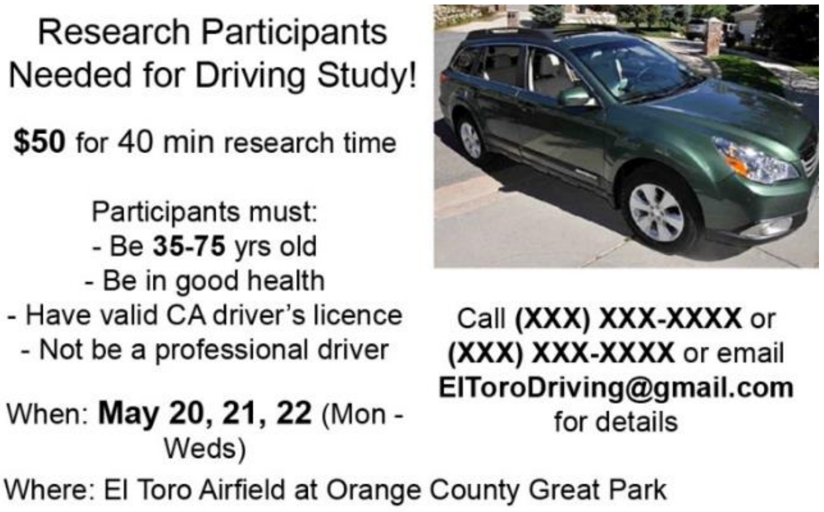
Participants will be compensated **$50** for their time. The study will last approximately 40 minutes and takes place on a closed driving course at the Orange County Great Park.

The study is taking place on May 20, 21, and 22 (Mon-Wed)

If eligible, please call (XXX) XXX-XXXX or (XXX) XXX-XXXX, or email **ElToroDriving@gmail. com** for further details and additional eligibility criteria.

Calls are accepted between 8am and 7pm Pacific time.

Daily Pilot (LA Times) Ad



Research Participants
Needed for Driving Study!

$50 for 40 min research time

Participants must:
- Be **35-75** yrs old
- Be in good health
- Have valid CA driver's licence
- Not be a professional driver

When: **May 20, 21, 22** (Mon - Weds)

Call **(XXX) XXX-XXXX** or **(XXX) XXX-XXXX** or email **ElToroDriving@gmail.com** for details

Where: El Toro Airfield at Orange County Great Park

Appendix H: El Toro Track Diagrams

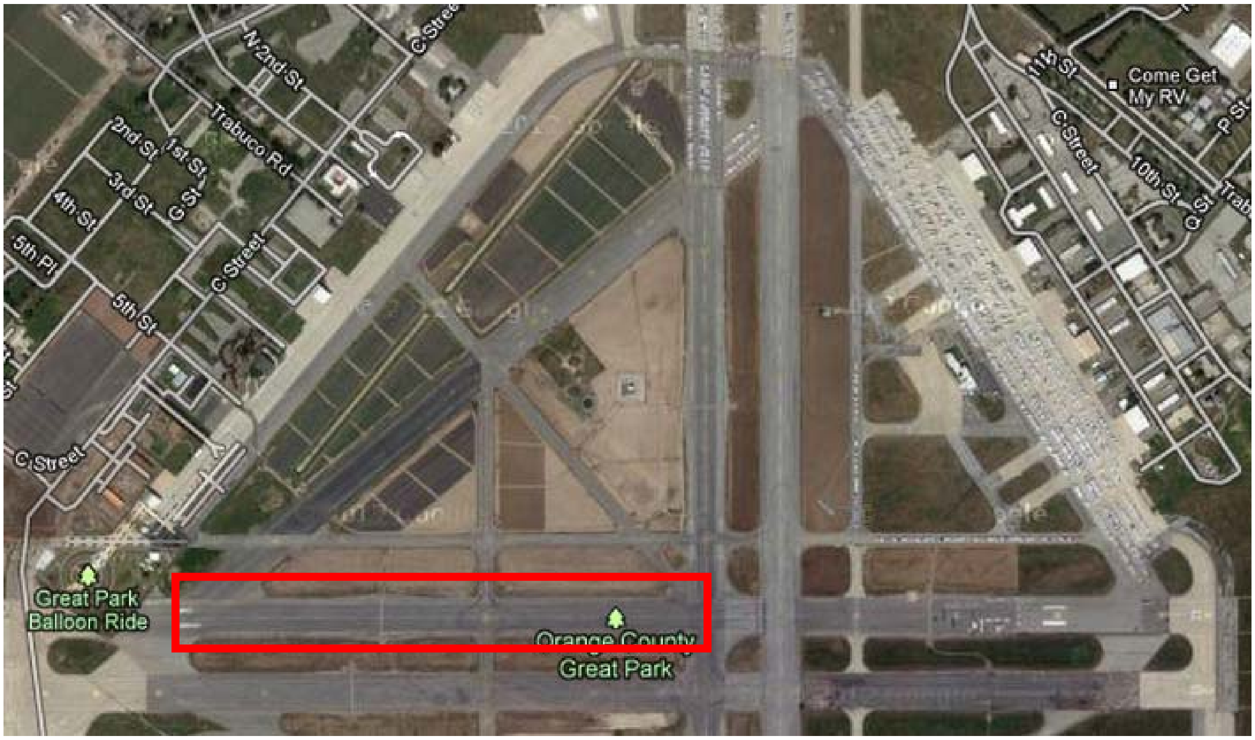


Figure H36. Aerial view of the El Toro Airfield track

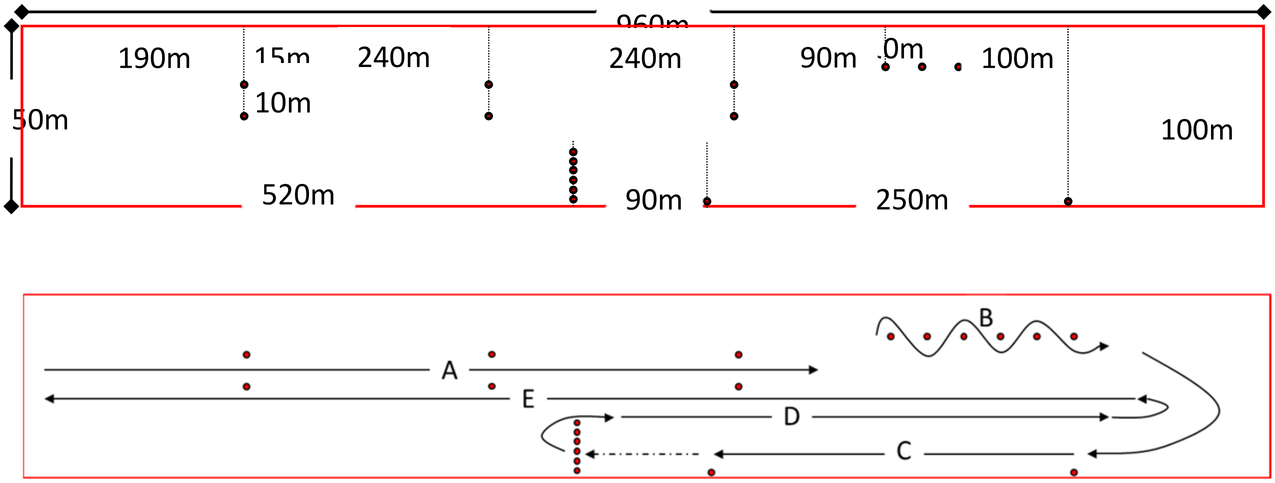


Figure H37. Schematic of the track layout and the course driven by the participants.

Appendix I: Site and Vehicle Photographs

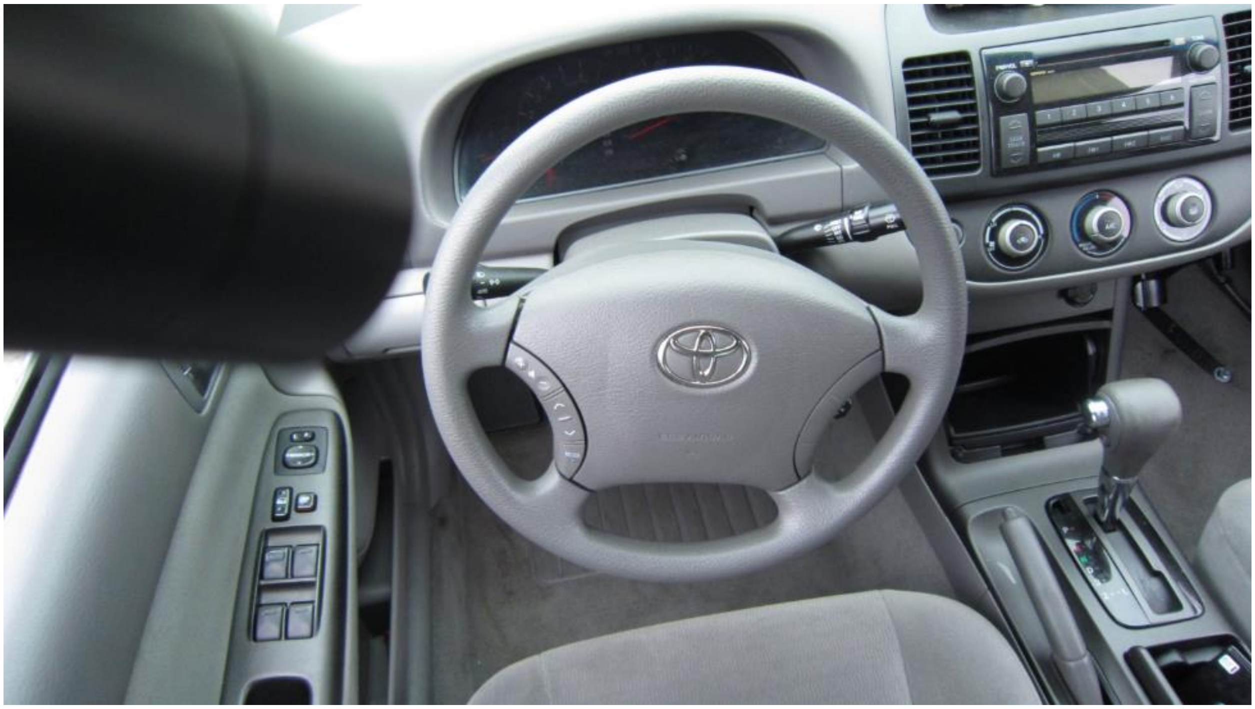


Figure I38. View of the overhead camera

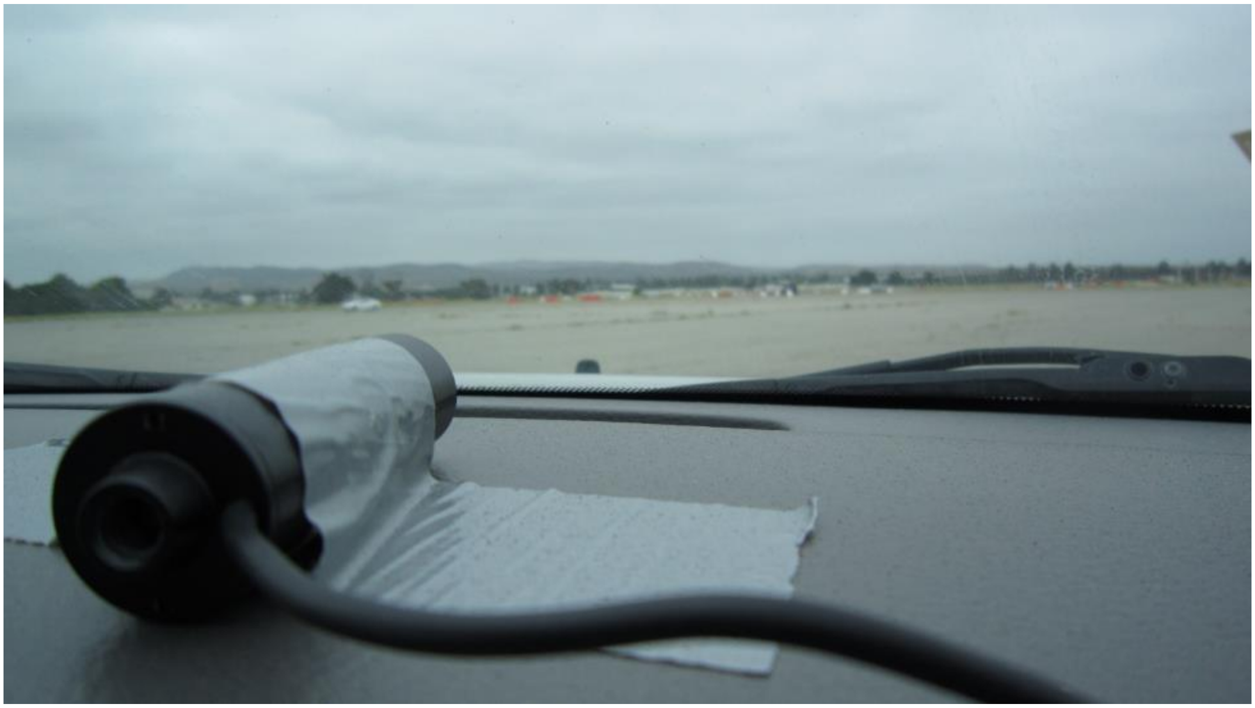


Figure I39. View of camera on dashboard looking out the windshield

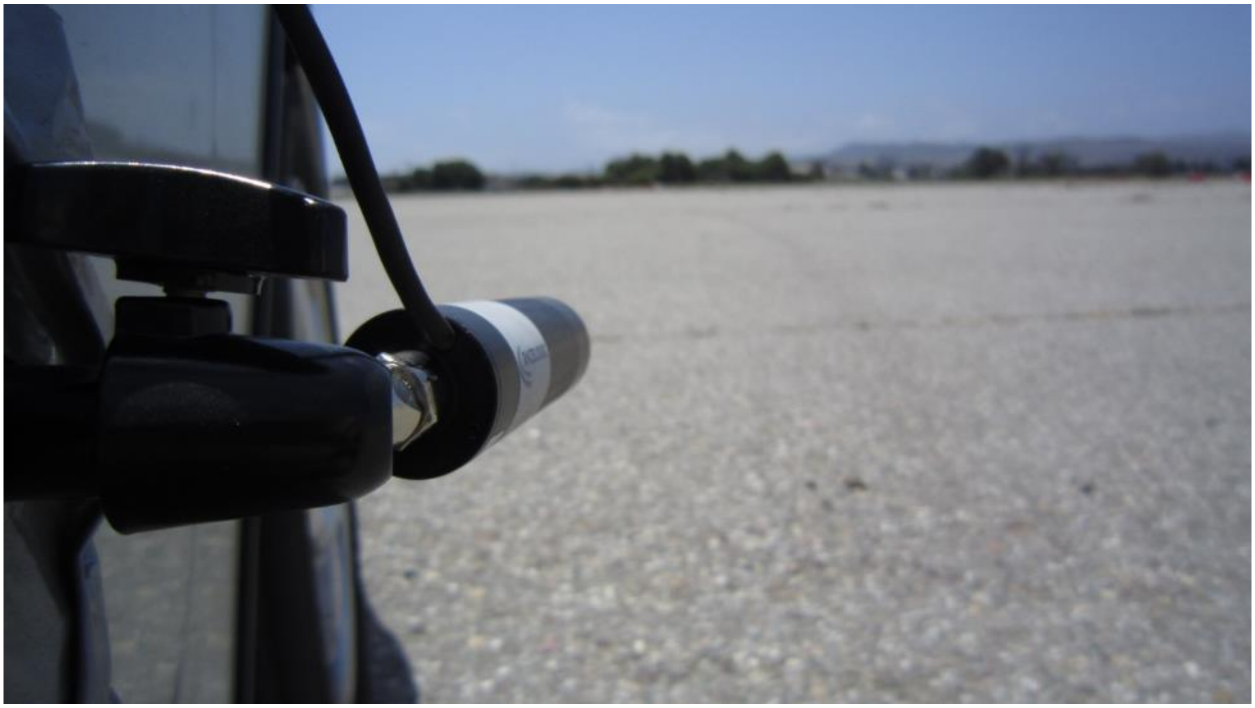


Figure I40. View of camera on passenger side door

Figure I41. 2005 Toyota Camry driven by participants

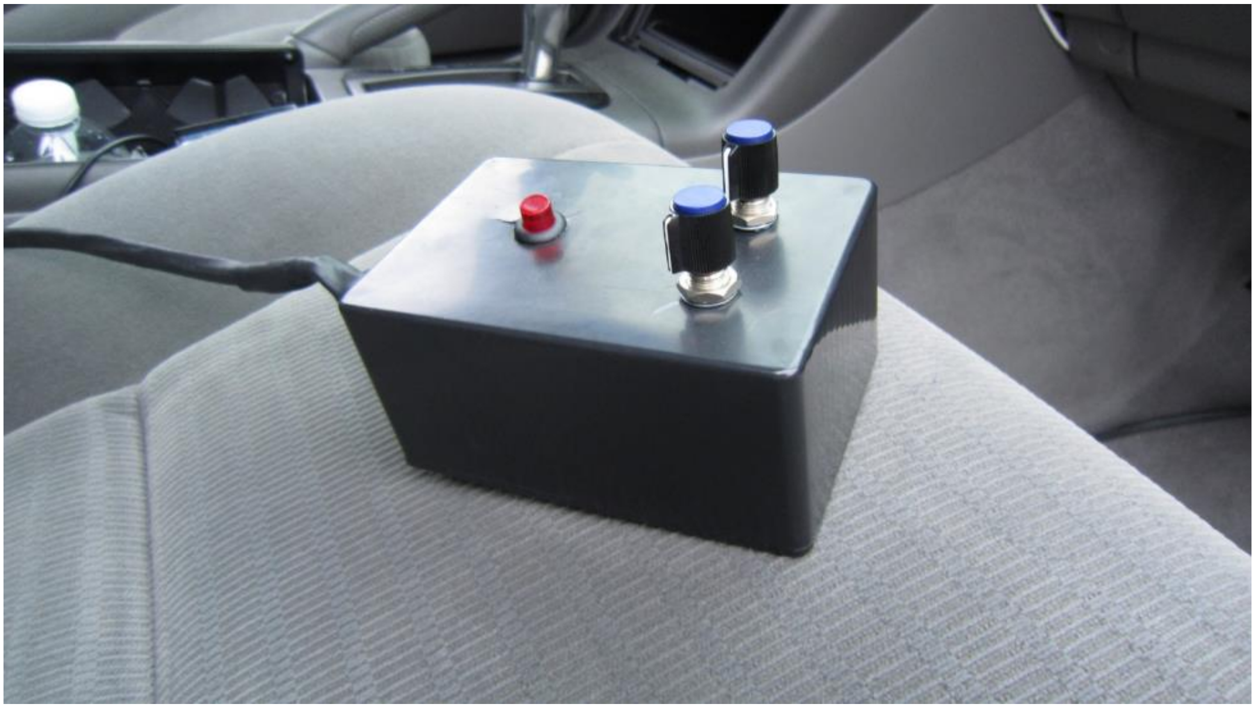


Figure I42. Facilitator's accelerator button and throttle controls

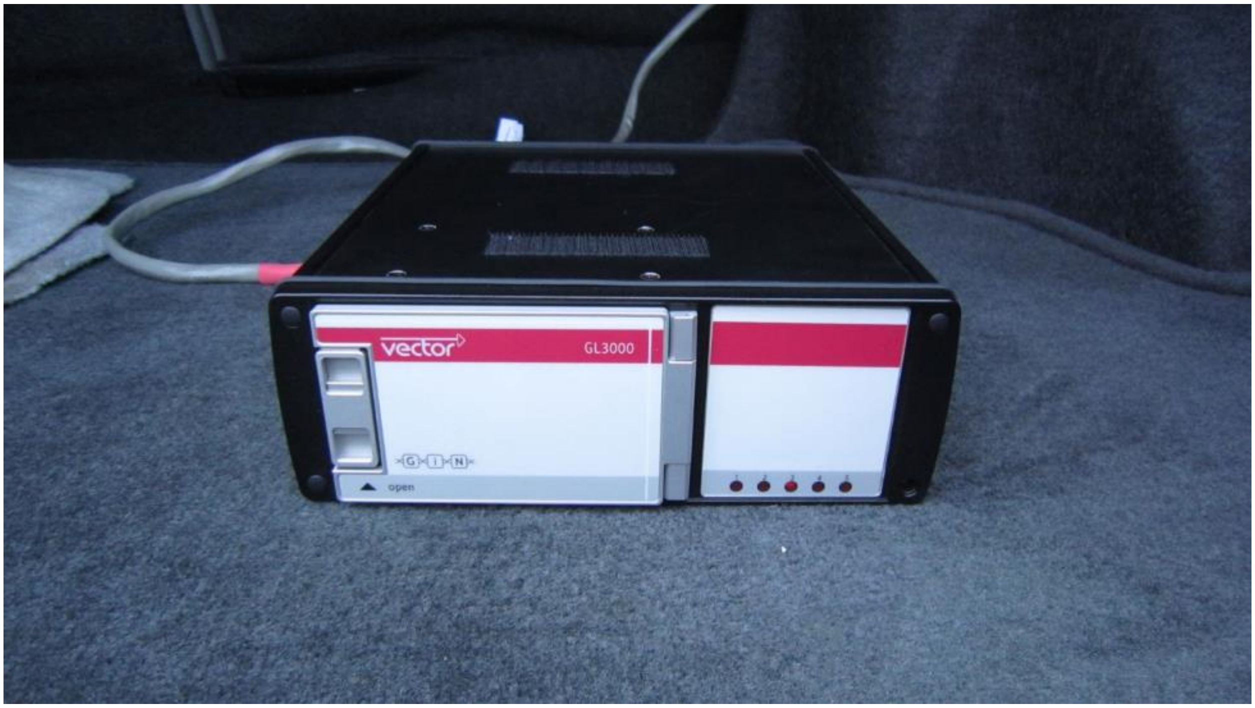


Figure I43. Instrumentation device in trunk of vehicle

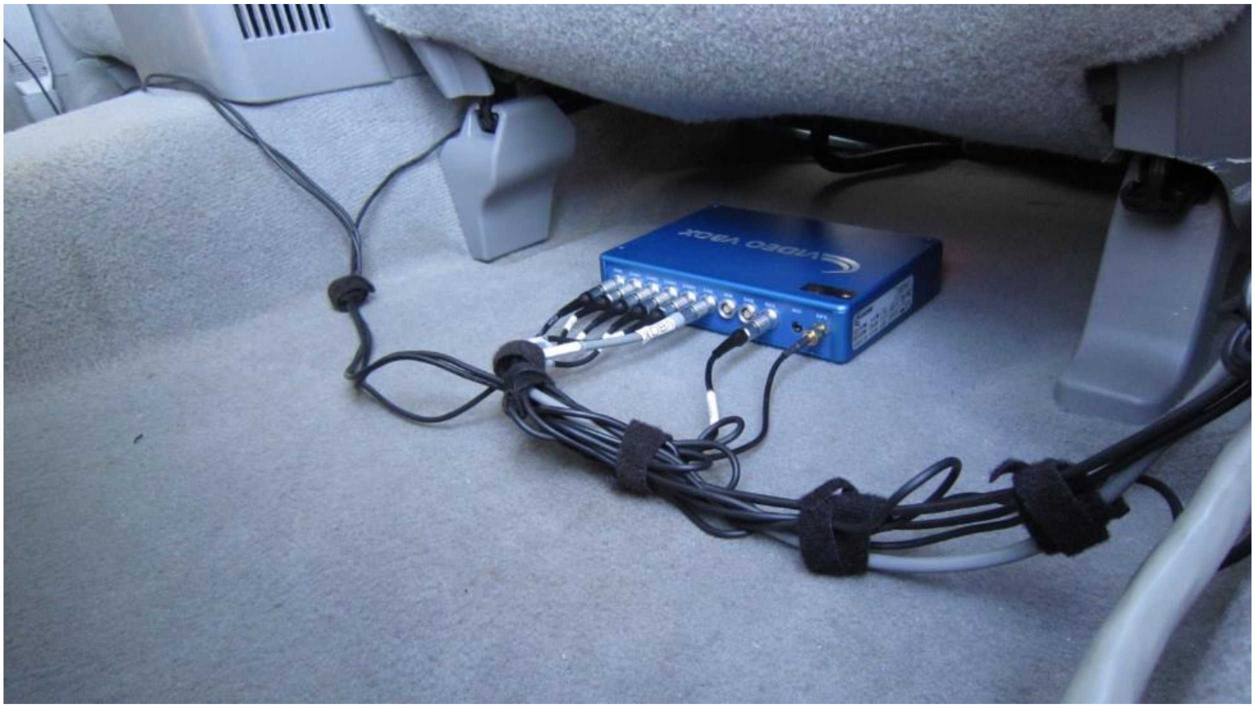


Figure I44. Instrumentation device underneath the front passenger seat

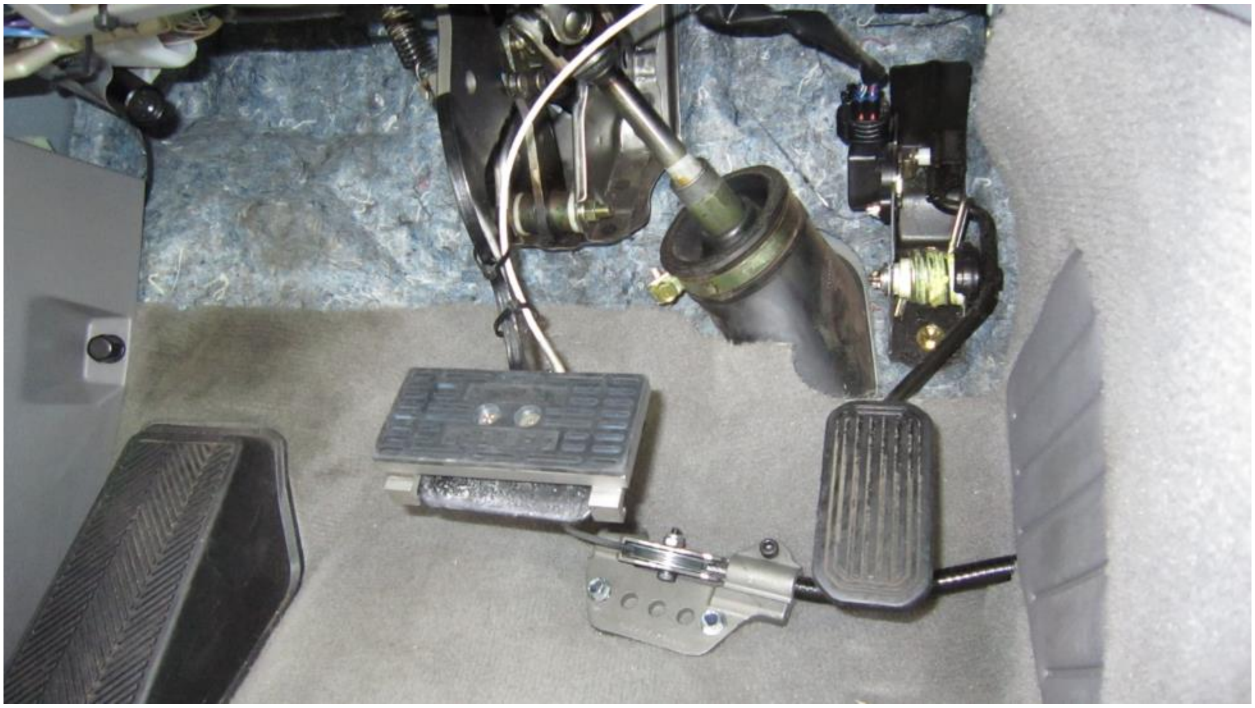


Figure I45. Driver-side break and accelerator, sensors, and pedal camera

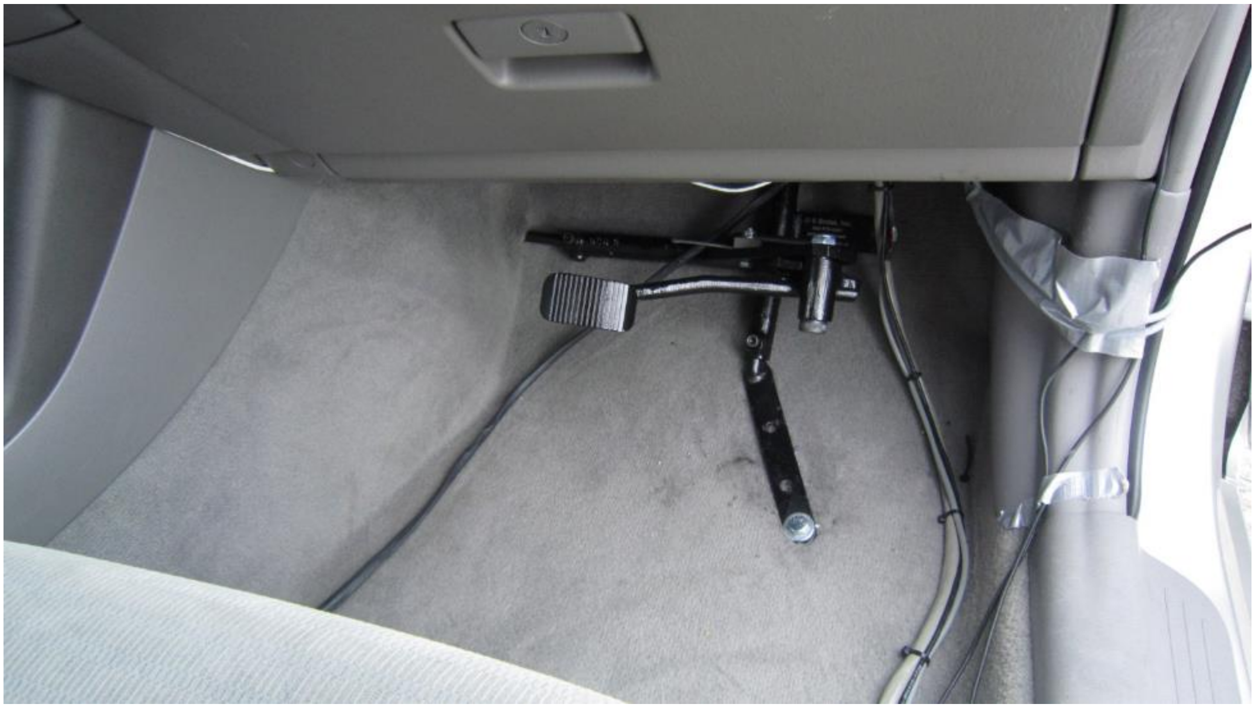


Figure I46. Passenger-side redundant brake pedal

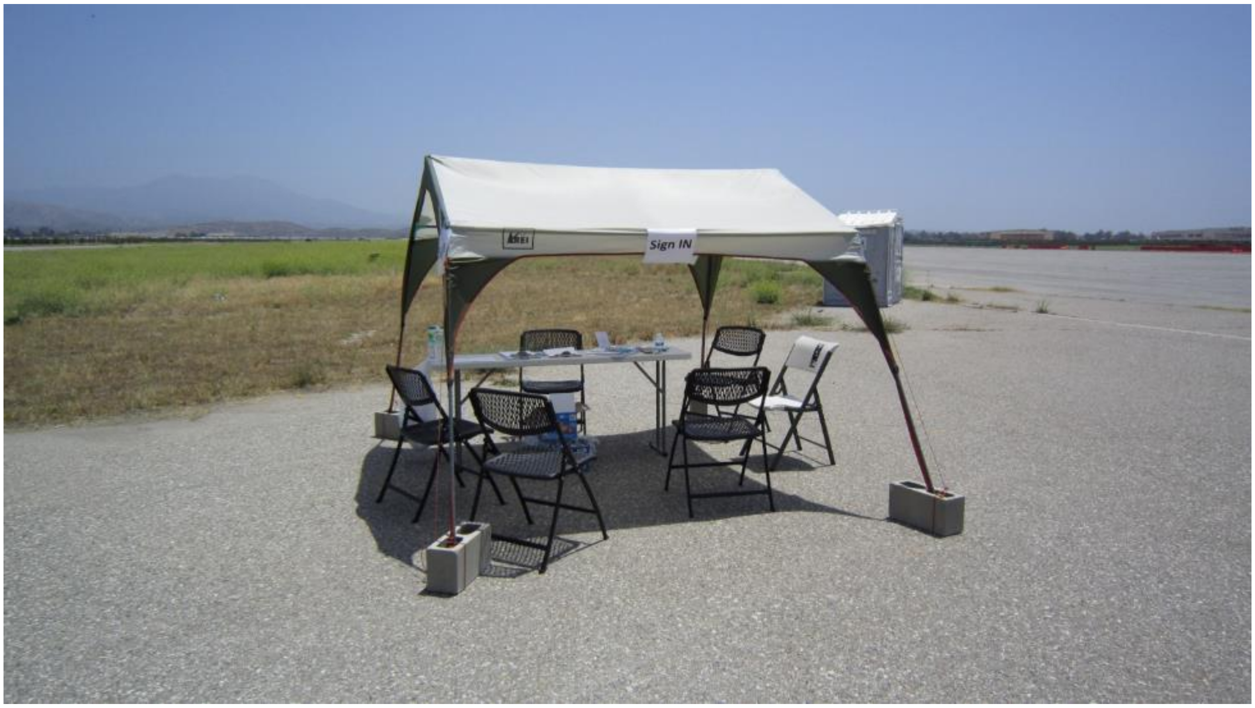


Figure I47. Intake tent

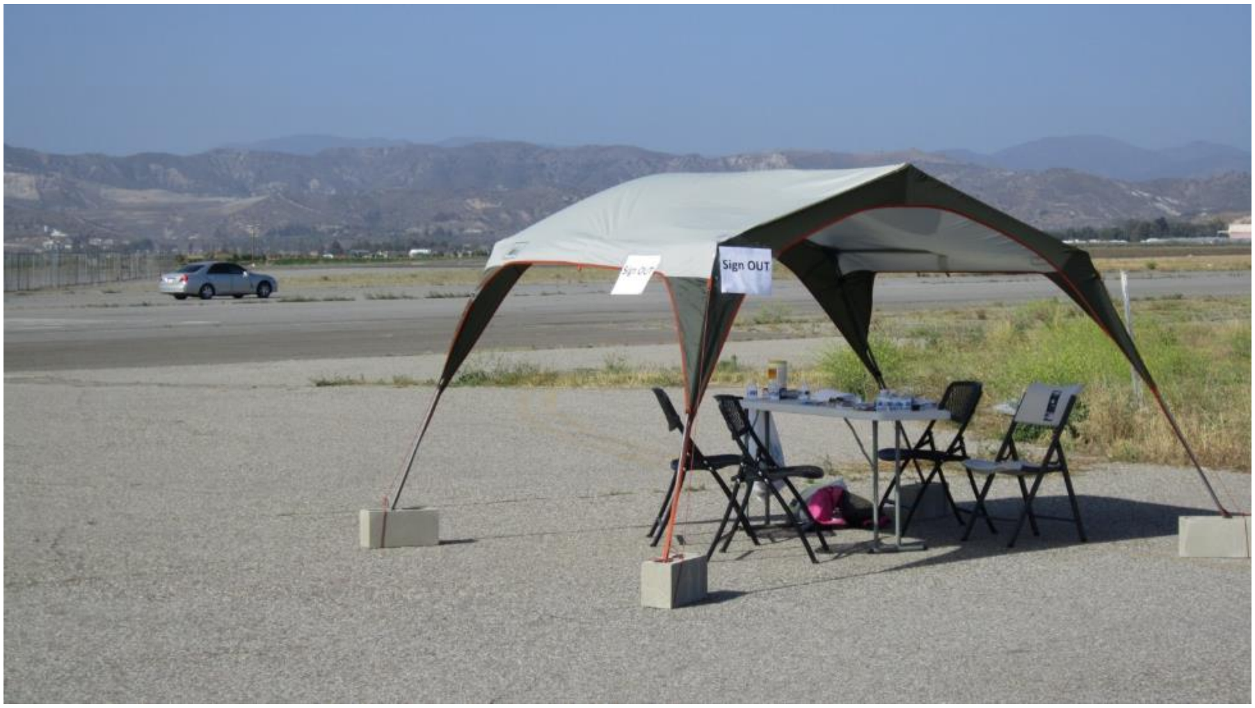


Figure I48. Sign out tent

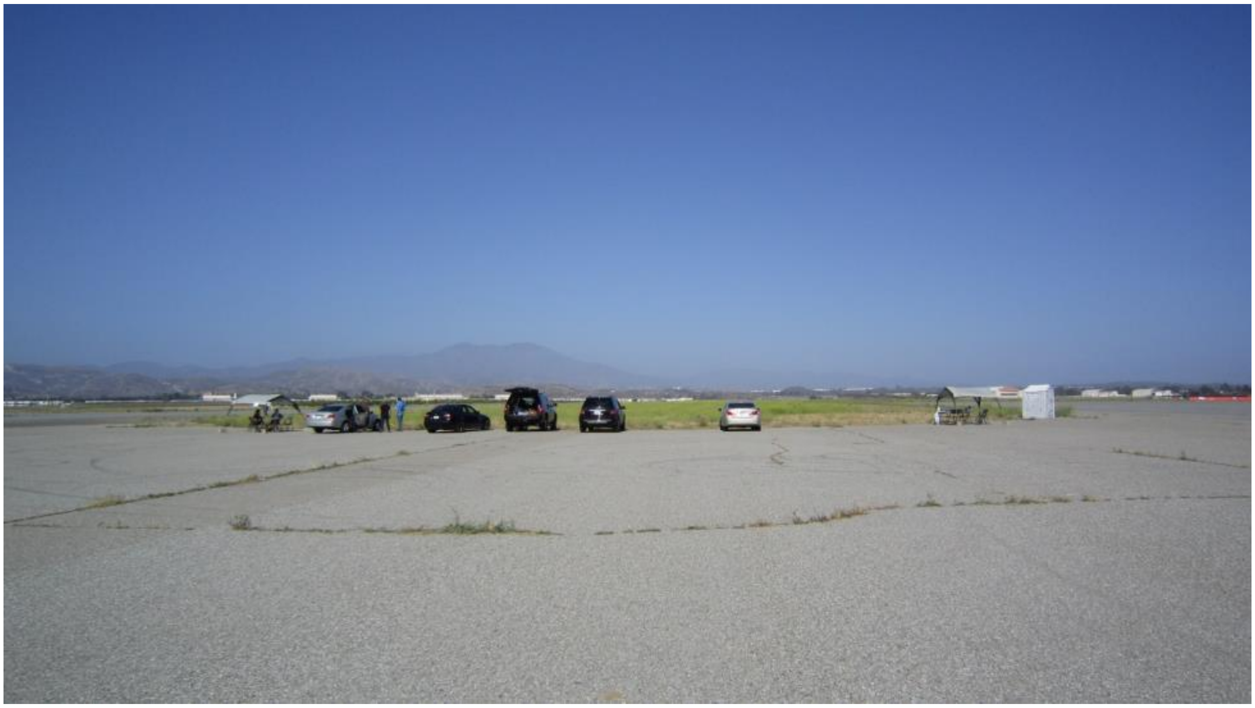


Figure I49. Complete set up, with the intake tent on the right and sign out tent and track on the left

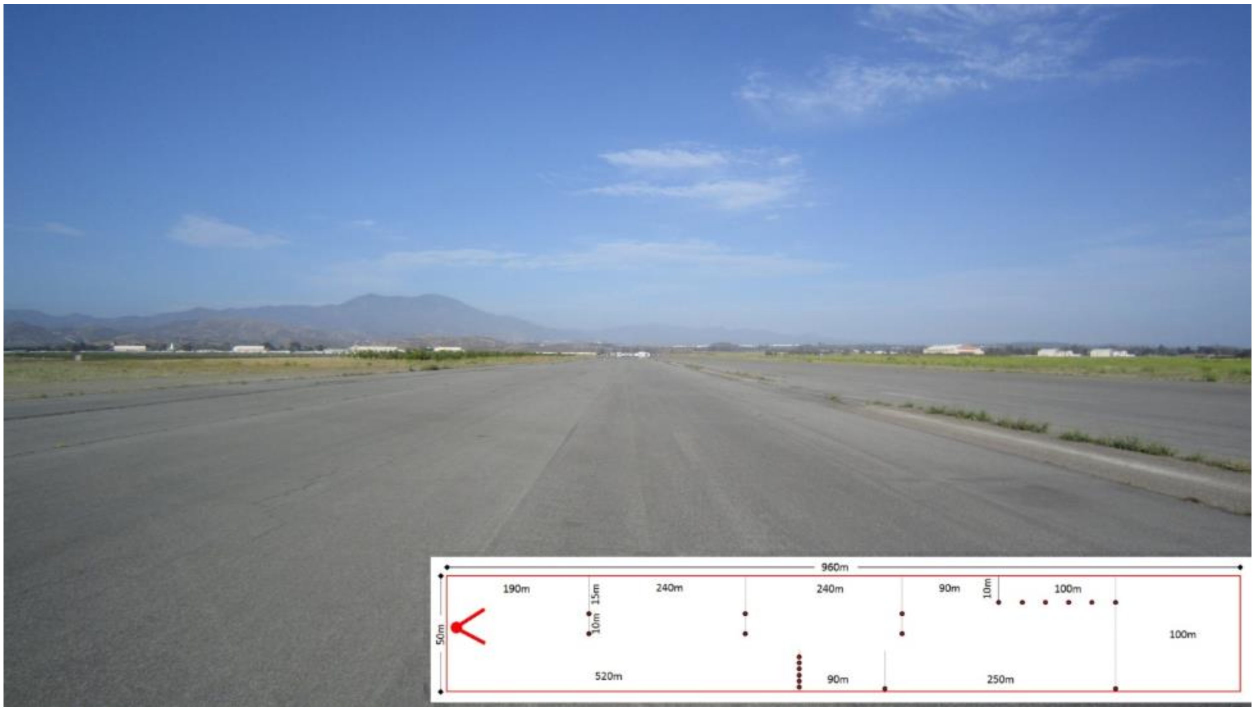


Figure I50. View looking eastward down the track

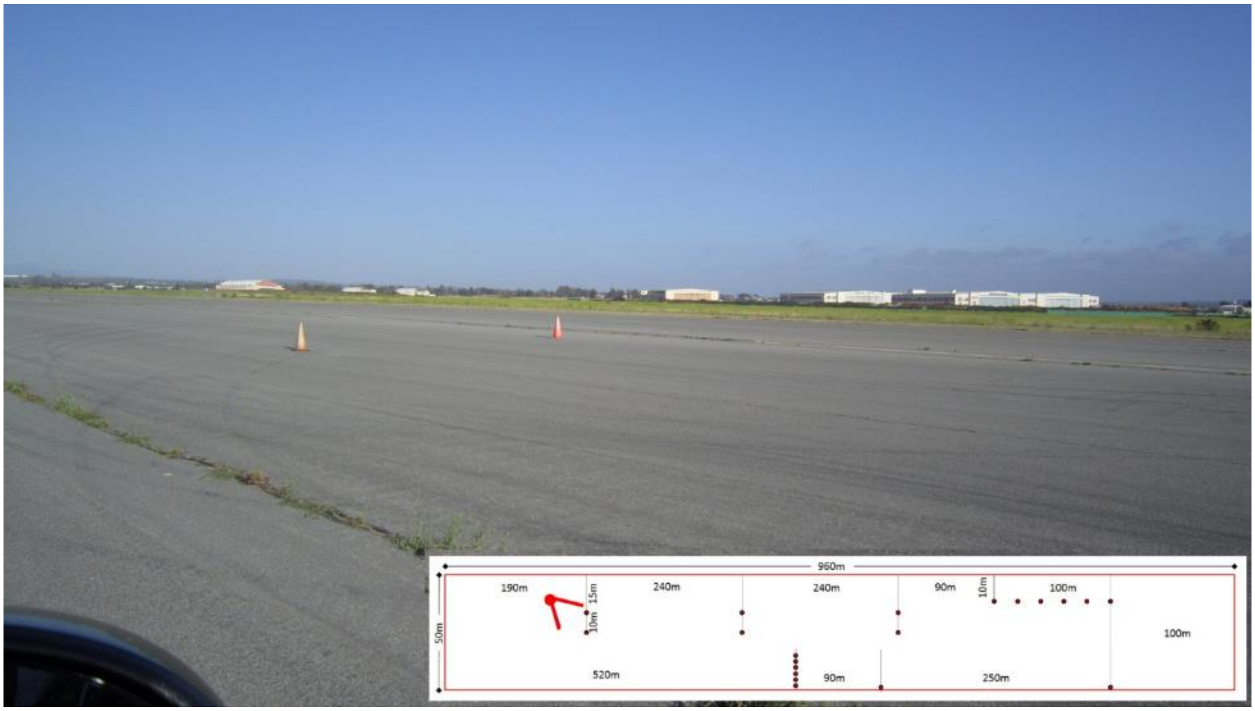


Figure I51. First set of cones encountered during the training

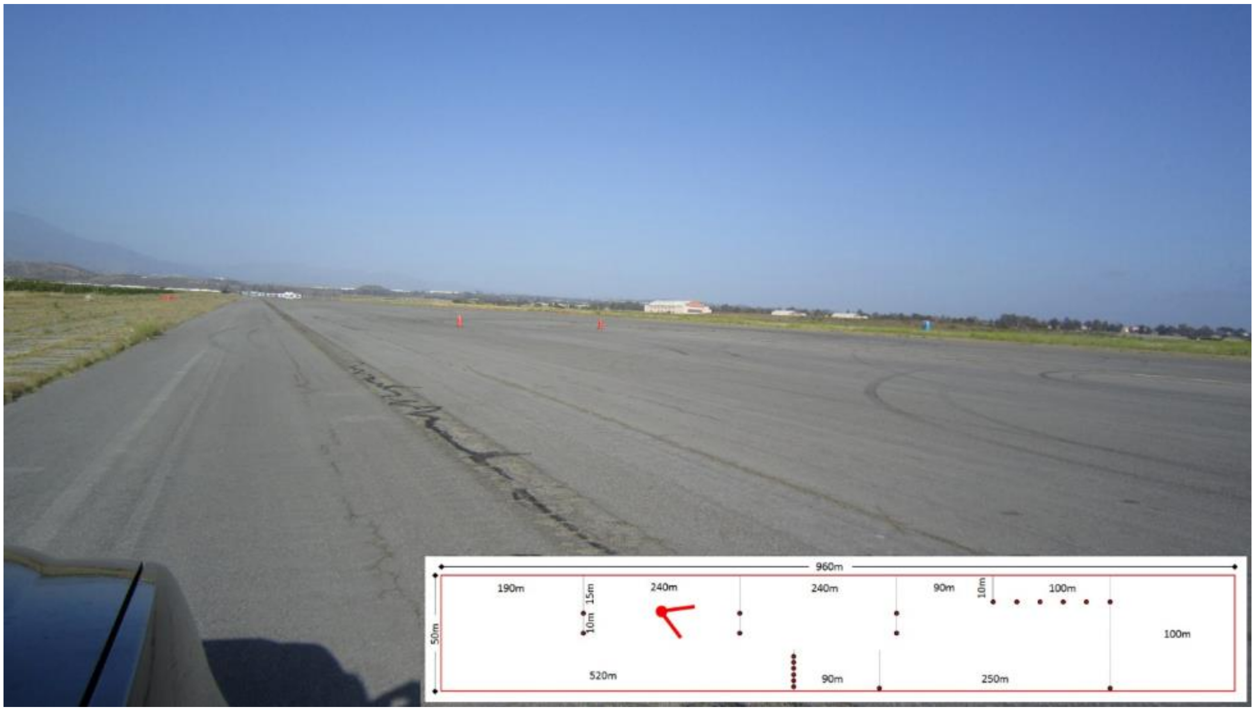


Figure I52. Second set of cones encountered during training

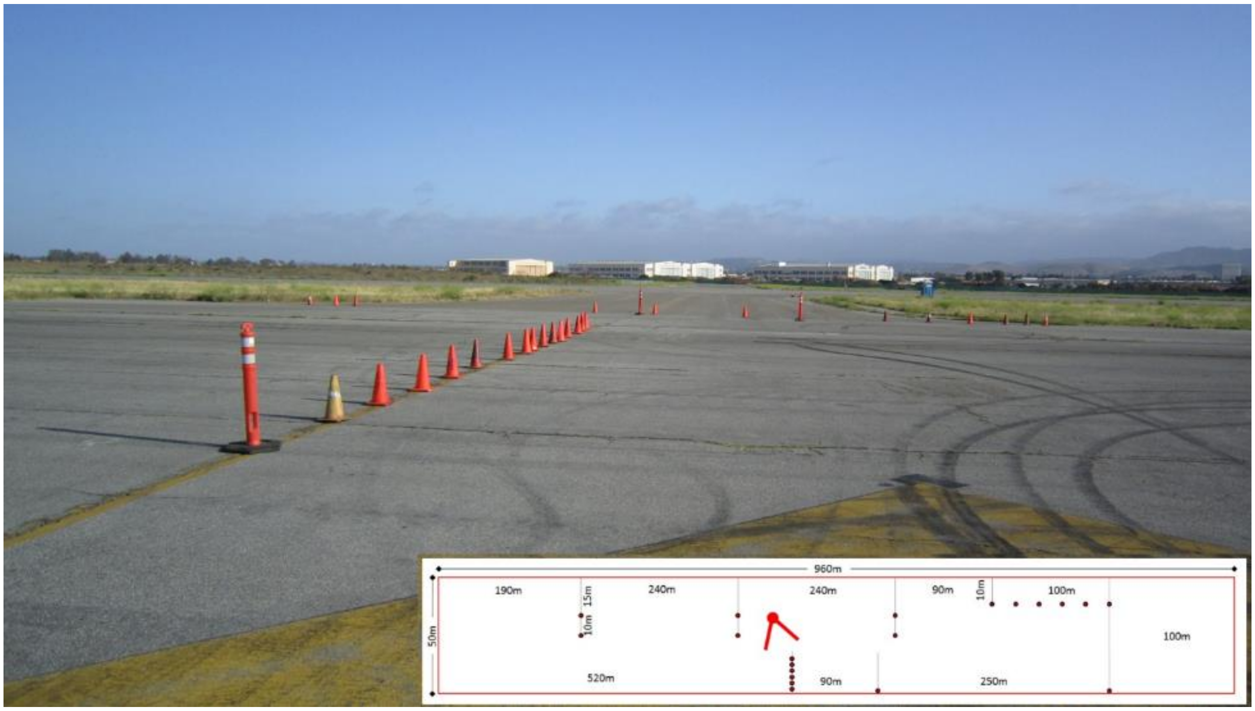


Figure I53. Cone wall used in the initial UA event

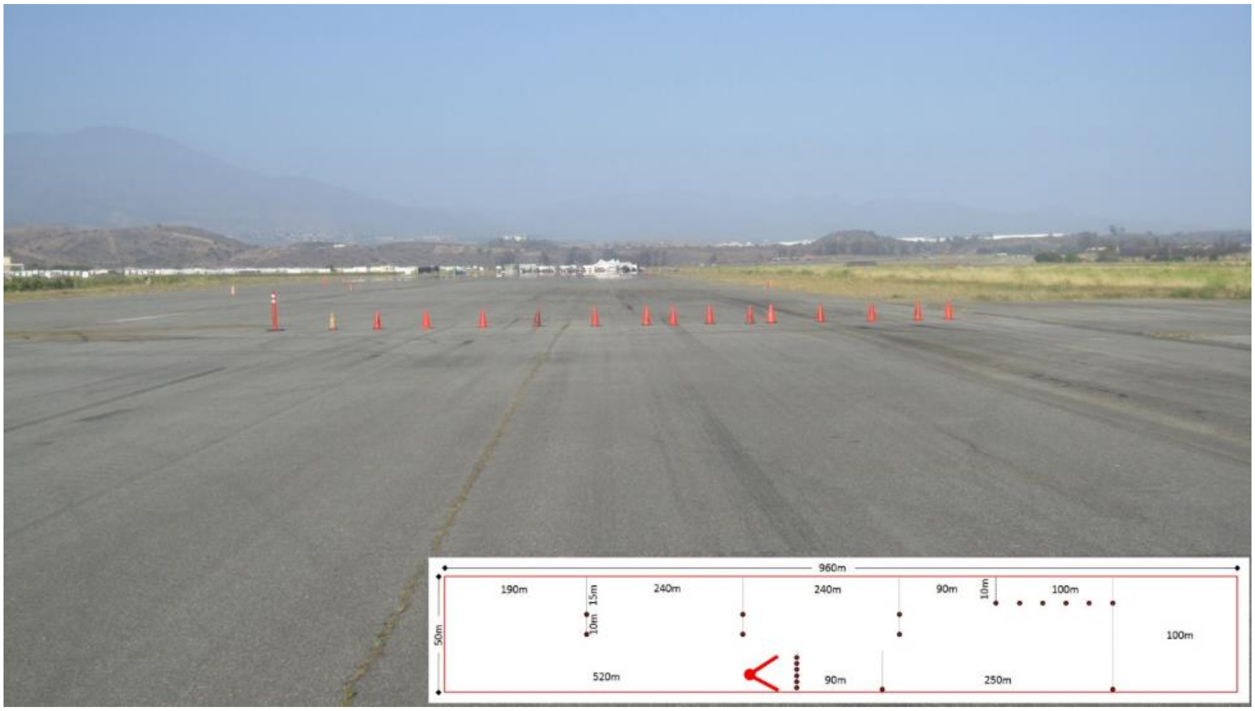


Figure I54. Cone wall used for the initial UA event looking eastward down the track

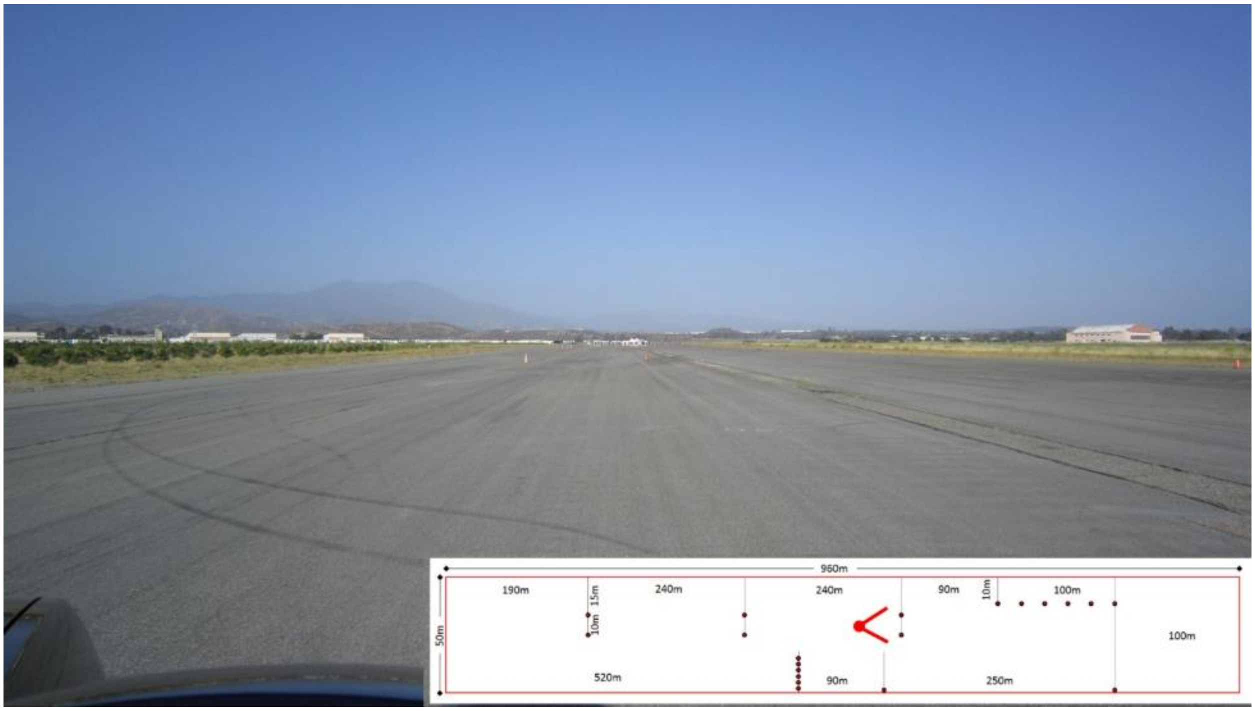


Figure I55. Third set of cones encountered during part A of training

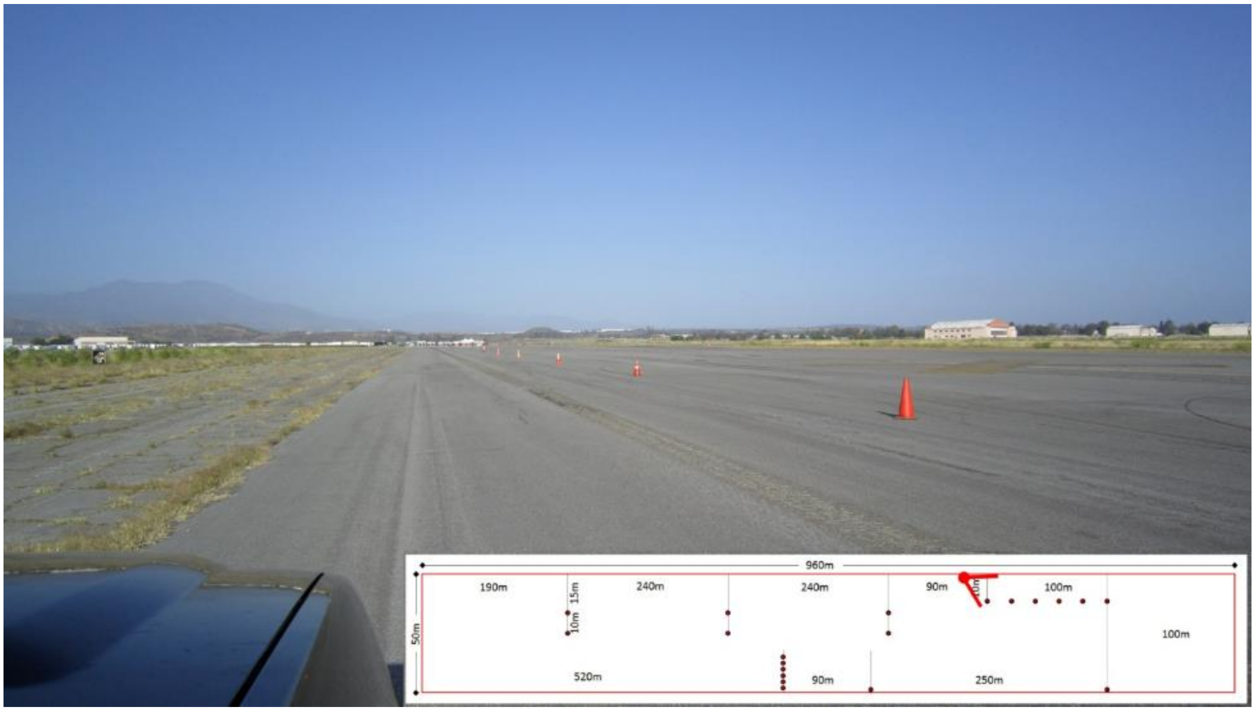


Figure I56. Beginning of the slalom section (part B) of the training

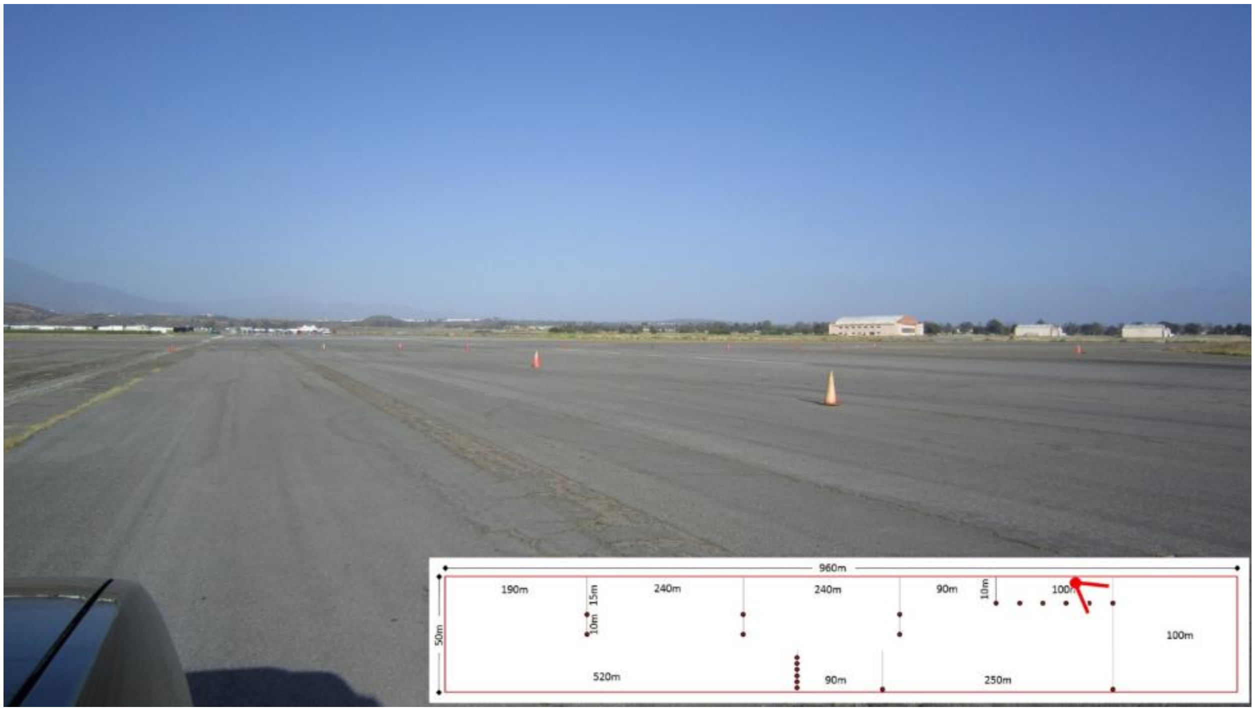


Figure I57. End of the slalom course (part B) and end of the track; turn-around point and beginning of UA event (part C)

Appendix J: Exit Questionnaire Responses and Comments

Participant 1:
“Made me more conscious of thinking about what to do when unexpected things happen while driving. Having someone in the [car] made me think about their safety as well as my safety.”

Participant 2:
“This was great. It's a good reminder if it should happen again of what to do. Today I didn't think about neutral. I was startled, then I couldn't stop it from accelerating more and then I realized he was controlling it. I think I verbalized it. Thank you for the experience today.”

Participant 3:
“Great instructions on course.”

Participant 4:
“It went very well.”

Participant 5:
“Interesting but uncertain as to purpose and outcome.”

Participant 6:
N/A

Participant 7:
N/A

Participant 8:
“I did not know that you should put vehicle in neutral and then hit the brake. Thank you for this new and helpful safety info.”

Participant 9:
“I kept pumping the brake after car finally stopped!”

Participant 10:
“Fascinating. Learned helpful and new info on ‘neutral’.”

Participant 11:
“When there is a sudden acceleration have the car manufacturer put the car temporarily in neutral.”

Participant 12:
“I learned to put my car in neutral for unintended acceleration and never pump the brakes!”

Participant 13:
“I was quite surprised and it grabbed my attention.”

Participant 14:

“Nice time. Great location. Great weather.”

Participant 15:
N/A

Participant 16:
“I really enjoyed it. Having received my license in 1975, before anti-lock brakes, I was taught to pump brakes and put car in neutral.”

Participant 17:
“Good learning experience.”

Participant 18:
“Was just interested in how the car was set up which was explained to me.”

Participant 19:
“People should be taught about going into ‘NEUTRAL’ and cars should be unable to go into reverse when moving forward!”

Participant 20:
“Felt lucky to be involved in a study like this. My experience might help somebody else.”

Participant 21:
“Unexpected experience. Stressful. Concerned for safety. Concerned about about loss of control with car equipment.”

Participant 22:
N/A

Participant 23:
N/A

Participant 24:
N/A

Participant 25:
“All was fine.”

Participant 26:
“Solution to problem is to teach Loft [sic] pedal braking at all times, turn off ignition.”

Participant 27:
N/A

Participant 28:
“It was fun, and all new drivers should have to go through a course like this. Anyone over 65 years of age should have to take this course.”

Participant 29:
“Was very difficult to stop the car without going into neutral.”

Participant 30:
“Very interesting to know you put it into neutral.”

Participant 31:
“It's an interesting study. Scary/anxious experience of losing control of speed/braking of car. I'm glad I was able to participate in this study!”

Participant 32:
N/A

Participant 33:
N/A

Participant 34:
“I've learned something today.”

Participant 35:
“Well it was fun and very educational. I learned a lot about sudden acceleration and what to do if it happens. As an owner of a 2003 Camry, I was amazed at the difference of braking between the two models.”

Participant 36:
“Very interesting and quite informative.”

Participant 37:
“I saw in the newspaper about gas pedal getting stuck. If this happened to me, I would put it in ‘N’.”

Participant 38:
“It was interesting to see how the car behaved with hard acceleration and braking to stop it.”

Participant 39:
N/A

Participant 40:
N/A

Participant 41:
“Heads up about that there might be some unexpected acceleration.”
Participant 42:
“Good study.”

Participant 43:
“Very interesting! I appreciated the life experience!”

Participant 44:
N/A

Participant 45:
N/A

Participant 46:
“It was a lesson. Taught me a lot.”

Participant 47:
“Interesting. Did not know that pumping brakes greatly diminished braking effectiveness.”

Participant 48:
“When watching the news about this issue a couple of years ago, I wondered why that driver (the guy on the freeway) didn't shift into neutral and turn off the engine! Then when I just experienced UA I didn't even think of that as an option because of the surprise/shock (shocked the shit out of me) of the event. After, I remembered I should have shifted into neutral. That guy's [officer who died] an idiot, you know, he should at least tried that. Now I put myself into kind of his position and I can see how he might have just freaked out because you have no chance to think straight."

Participant 49:
“It was neat. I am happy to help make vehicles safer for consumers. Nice staff. Joel was cool.”

Participant 50:
“Quite the study!”

Participant 51:
“It was fun actually.”

Participant 52:
“Great day!”

Participant 53:
“I have never thought about putting my car in neutral while my car is accelerating because I thought it would fishtail or harm my engine.”

Participant 54:
“FUN”

Participant 55:
“It was a fun study. Enjoyed it.”

Participant 56:
“I initially braked after the sudden accel then lifted foot off brake. I think because I was reacting to the way I would if I suddenly hit a patch of ice or oil. Reflex is to brake, but if car won't stop, you lift off brake and pump brake to stop. Training, explanations, and staff was [sic] great!”

Participant 57:

"On last brake move, I kept trying to pump break hard to get car to stop."

Participant 58:
"Under different conditions with other vehicles surrounding me, my response would be much more different."

[Participant clarified that they would have been more surprised]

Participant 59:
"On last brake pump I pumped one more time as car would not stop."

[Vacuum depleted and UA occurred]

Participant 60:
"Had fun."

Participant 61:
"I learned not to pump when any car unintendedly accelerate [sic]."

Participant 62:
"Interesting to see the car's reaction to different reactions to driver. I found I was unnerved by trying to react."

Participant 63:
"Great that you investigate. I think that all studies, testing and analysis is so valuable. I suggest conducting the same study on hills; people's reaction may be different and maybe cars tend to have more of those [UA] events on hills."

Participant 64:
"During the 1, 2, 3 brake exercise [vacuum depleted and UA occurred], I used all of my body weight (260 lbs) to stop the vehicle from accelerating and it still kept moving forward, fighting me. I felt an adrenaline rush and was shocked and afraid."

Participant 65:
"It was great."

Participant 66:
"Great test."

Participant 67:
"It was an 'Oh my God am I dying' moment. I think I went into shock and didn't react in any other way except pressing on the brakes. Good to learn that 'place the stick on Neutral then hit the brakes' trick --> Thanks!"

Participant 68:
"Although I was unprepared it was educational and interesting. Educationally for my 'driving education.'"

Participant 69:
"Glad to know you all are looking out for us drivers and always working to make our vehicles better."

Participant 70:
“Was fun.”

Participant 71:
“Pumping the brakes is common for cars with air in the brakes.”

Participant 72:
“It was informative and fun. Nice folks!”

Participant 73:
“This one time in an '81 Cadillac Coupe de Ville the brakes gave out at highway speed and pumping the brakes helped put brake fluid into play and I came to stop and out of danger.”

Participant 74:
“Good experience and learned a few driving tips as well.”

Participant 75:
“Was not expecting the hard brake.”

Participant 76:
“Learned what to do if unattended [sic] acceleration occurs!”

Participant 77:
N/A

Participant 78:
“Why did you have them pump the brakes?”

Participant 79:
N/A

Participant 80:
“It was fun and educational.”
Participant 81:
“Fun.”

Appendix K: A Vehicle Description Report Prepared by Steve Loudon

STUDY OF DRIVER RESPONSE TO UNINTENDED ACCELERATION EVENTS

Vehicle Setup and Data Acquisition

STEVE LOUDON

April 12, 2013

Table of Contents

1 Introduction 108
2 Data Acquisition System 108
  2.1 Vector CANtech GL3000 109
    2.1.1 ECM Input Signals 109
    2.1.2 External Sensors 109
    2.1.3 Vehicle CAN Messages 110
    2.1.4 GL3000 Output 110
  2.2 Racelogic Video VBOX Pro 110
  2.3 UA Event Simulator 110
3 Vehicle Preparation 111
  3.1 Data Acquisition Installation 111
  3.2 Vehicle External Sensor Installation 113
  3.3 Passenger Brake Redundant Brake 117
4 Pre-test Vehicle Checkout 118
5 Daily Vehicle Checkout 118
6 Appendix – Data collected 118

1 Introduction

This report provides a description of the vehicle preparations that were made for a research experiment that was conducted on May 19, 20, and 21, 2013. This test was conducted at the Orange County Great Park. The details of the test can be found in a separate report. The vehicle chosen was a 2005 Toyota Camry with a 4 cylinder engine (engine code 2AZ-FE). The vehicle was equipped with a data acquisition system as well as components that allowed the researcher to simulate a UA event. Described below are the components and procedures used to equip the vehicle for this test.

2 Data Acquisition System

The data acquisition system is comprised of Racelogic's Video VBOX Pro, Vector CANtech's GL3000, vehicle wiring, and external sensors. This system was setup so that video images could be captured and coordinated with analog and digital signal measurements as well as vehicle CAN communication signals.

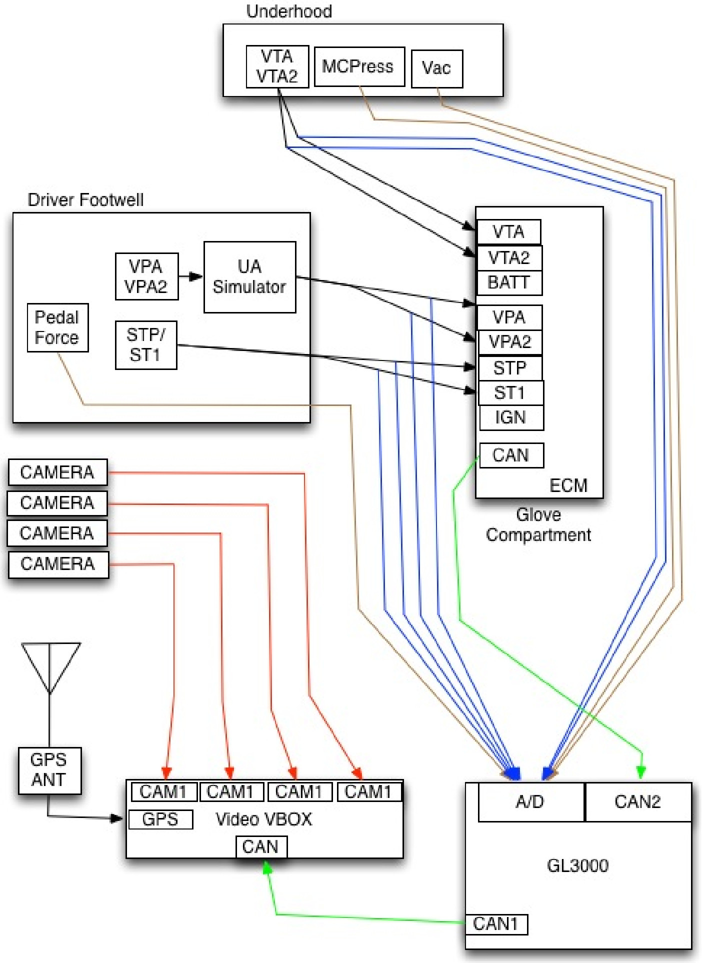


Figure 1 – System Level Wiring Diagram

The figure above shows at a system level the data acquisition systems, external sensors and wiring that was installed in the test vehicle. In the sections below, the components are described in more detail.

2.1 Vector CANtech GL3000

The GL3000 is a data acquisition system that can convert Analog and Digital signals and then construct CAN messages containing the converted data. This data is then transmitted on a CAN channel. Additionally, the GL3000 receives and rebroadcasts CAN messages from other sources. The GL3000 also served as the timekeeper providing a timestamp signal in a CAN message. The GL3000 was used to measure both internal vehicle signals as well as signals from external sensors added to the vehicle.

2.1.1 ECM Input Signals

For this test, the following vehicle ECM (Engine Control Module) electrical signals were measured and rebroadcast on CAN: Accelerator Pedal Sensor – VPA and VPA2; Throttle Body Sensor – VTA and VTA2; Brake Switch Signals – STP and ST1; Battery Voltage – BATT; and Ignition Voltage – IGN.

Signal Name	**Minimum Voltage**	**Maximum Voltage**
Throttle Sensor 1 - VTA	0	5
Throttle Sensor 2 - VTA2	0	5
Accelerator Pedal Sensor 1 - VPA	0	5
Accelerator Pedal Sensor 2 - VPA2	0	5
Vehicle Battery – BATT	0	15
Vehicle Ignition – IGN	0	15
Primary Brake Switch – STP	0	BATT
Secondary Brake Switch – ST1	0	BATT

Table 1 – Measured ECM Signals

2.1.2 External Sensors

In addition to the ECM signals measured, the GL3000 was also used to measure the following sensors that were added to the vehicle: Brake Pedal Force Transducer; Master Cylinder Pressure Transducer; Vacuum Booster Pressure Transducer; and UA Event in Progress indicator.

The Brake Pedal Force Transducer that was used was a low profile transducer that was capable of measuring 0 to 500 lbs. of pedal force. It is in a low profile package that feels very much like a standard production brake pedal. A transducer display module was used as well to power the sensor and then amplify the output so that the data acquisition system can measure the signal.

The Master Cylinder pressure transducer measures 0 psi to 3000 psi and converts this signal to a 1-5 V output. It is powered by an 8-30 V input. This sensor was powered by the vehicle battery.

The Vacuum Booster pressure transducer measures -14.7 psi to 15 psi and converts this signal to a 0-5 V output. It is powered by an 8-30 V input. This sensor was powered by the vehicle battery.

Measurement Signal	**Minimum Voltage**	**Maximum Voltage**	**Minimum Physical Quantity**	**Maximum Physical Quantity**	**Units**
Brake Pedal Force - BRKPEDLAFORCE	0	10			lb
Master Cylinder Pressure - MCPRESS	1	5	0	3000	Psi
Vacuum Booster Pressure - VACBOOSTER	0	5	-14.7	15	Psi

Table 2 – External Sensors

2.1.3 Vehicle CAN Messages

The ECM’s CAN channel was also monitored and the engine RPM signal was read and rebroadcast.

2.1.4 GL3000 Output

After all of the previously described signals are captured that are put into CAN messages and broadcast on a separate CAN channel.

2.2 Racelogic Video VBOX Pro

The Video VBOX Pro is equipped with up to 4 camera inputs, an internal GPS receiver and processing engine, and CAN input. All of these inputs are collected and a video scene is created providing a composite view of all of the camera inputs as well as dials, gauges and text images of the GPS and/or CAN data. A single camera input is chosen as the main view and the other 3 can be inserted as Picture In Picture views on top of that main view. GPS data is used to determine vehicle location as well as vehicle speed and many other vehicle motion parameters. The system allows you to extract and log up to 32 of the CAN signals. These signals, in addition to being logged at 10 Hz, can be displayed in the composition video screen using dials, gauges and/or text overlays. Below is a screen shot of the composite video image chosen for this test.

The data that is collected is logged into a text file at 10 Hz. It was setup to start collecting data when vehicle motion was started and to complete a data acquisition event and file when the vehicle came to a complete stop.

2.3 UA Event Simulator

The signals VPA and VPA2 were logged by the Data Acquisition system. They could also be bypassed and a simulated pedal sensor input could be injected into the ECM. This input was used to create a simulated unintended acceleration (UA) event.

A digital signal of the switch input was also logged by the data acquisition system in a signal called Test Enable.

3 Vehicle Preparation

3.1 Data Acquisition Installation

To prepare the vehicle for the test, the aforementioned data acquisition equipment was installed in the vehicle.

The GL3000 was installed in the trunk and a vehicle wiring harness was created and installed along the passenger side floor to the location of the ECM – behind the glove compartment. All of the external sensors wiring were routed to the same location. This allowed the vehicle to maintain a production appearance.

The only visual indication of instrumentation in the vehicle was the cameras.

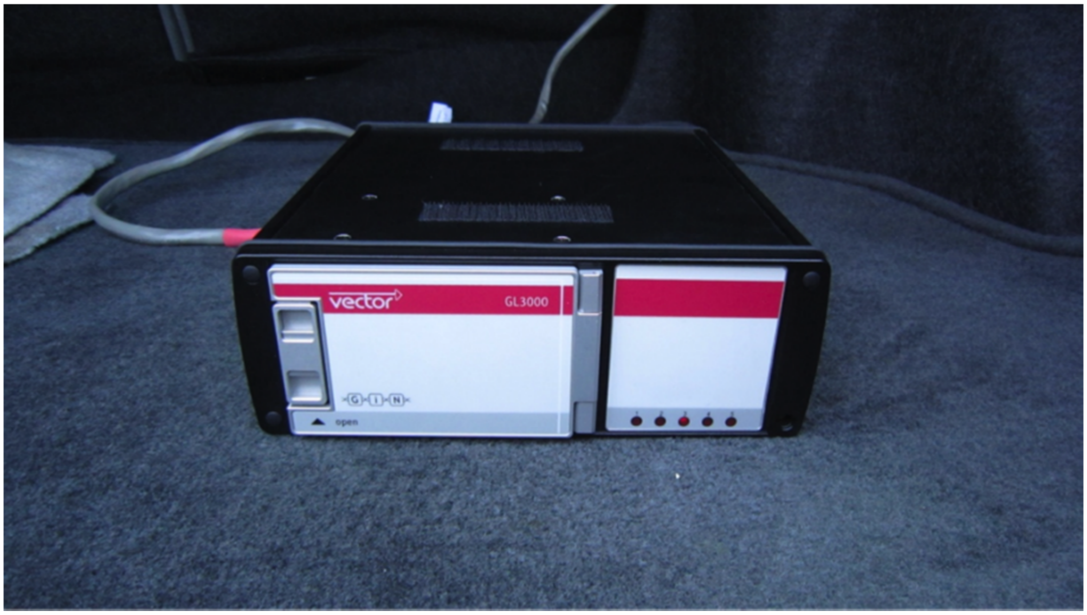


Figure 2 – GL3000 Data Logger

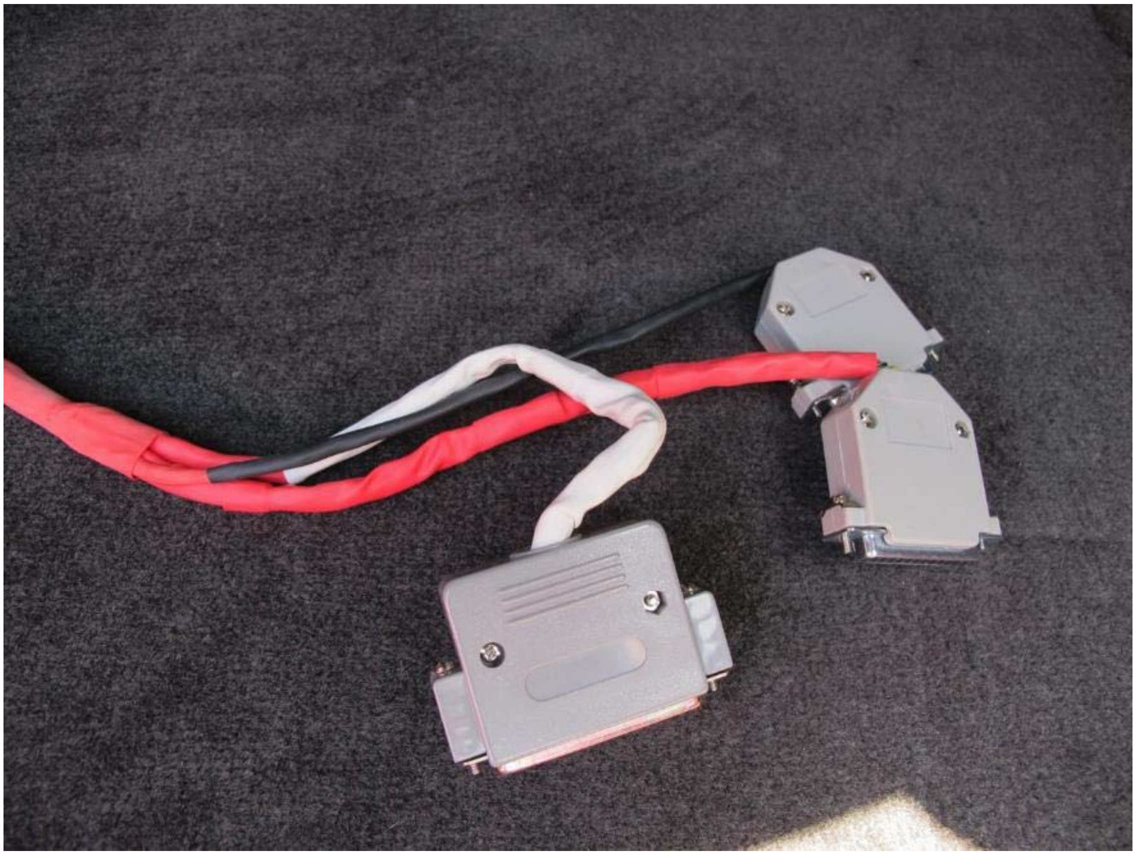


Figure 3 - GL3000 Wiring Harness Connectors

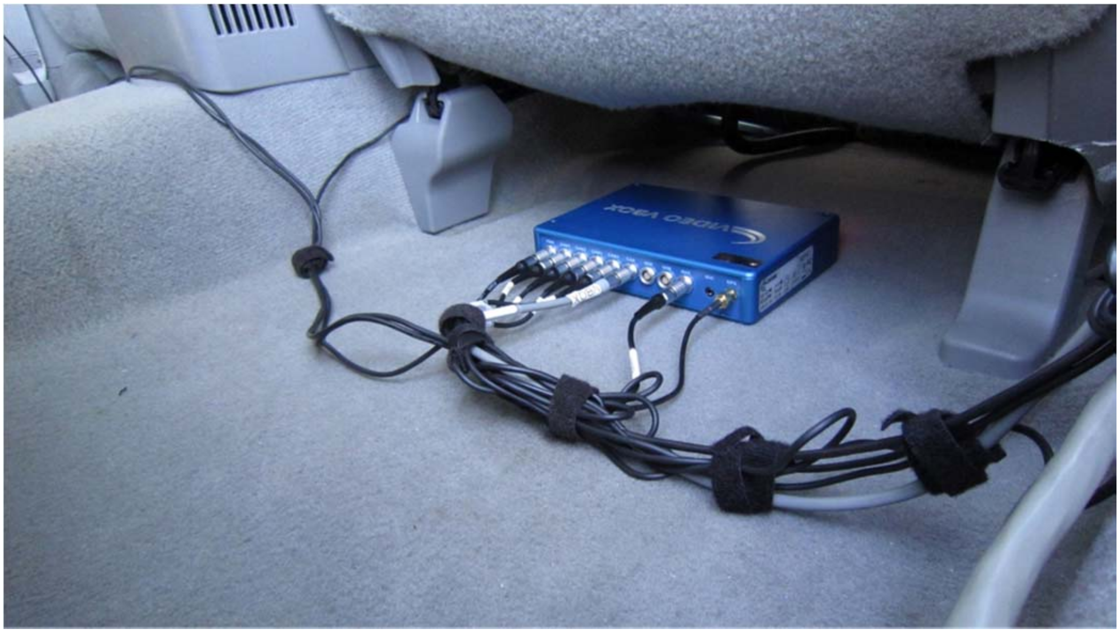


Figure 4 – Video VBOX Pro

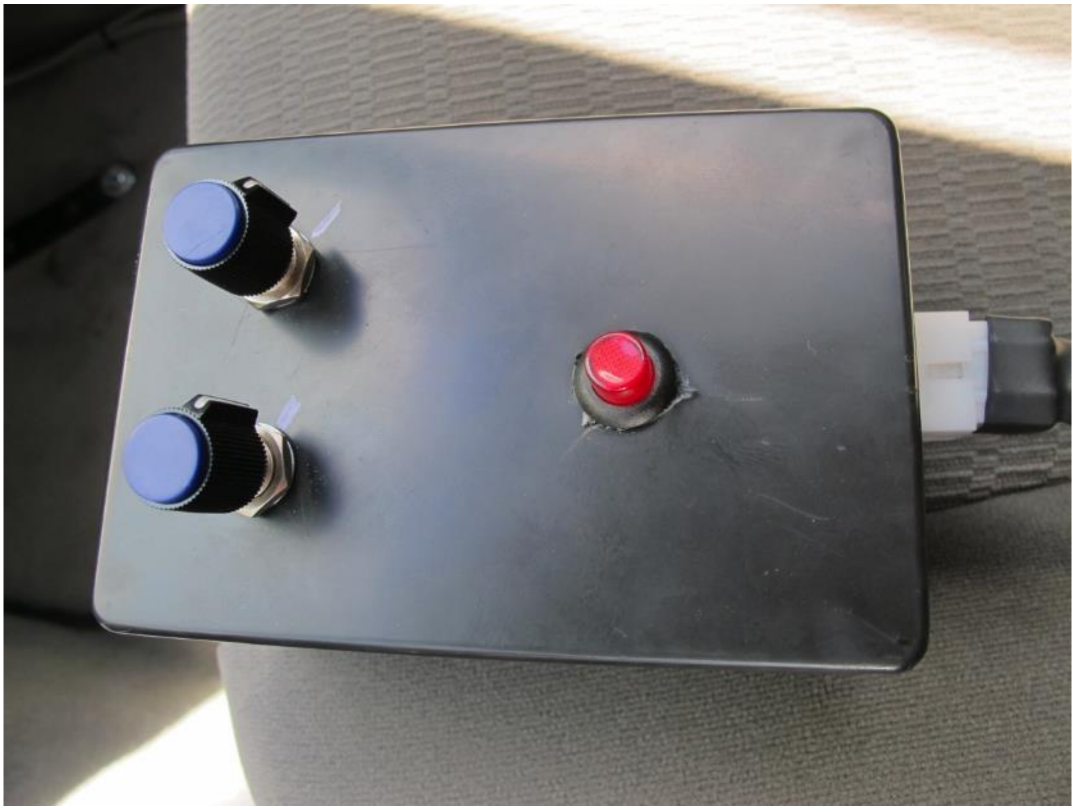


Figure 5 – UA Simulator Box

3.2 Vehicle External Sensor Installation

A mechanic was contracted to install all external sensors, including the Brake Pedal force Transducer, the Master Cylinder pressure transducer, and the Vacuum Booster pressure transducer.

The Brake Master Cylinder Pressure sensor was connected to the hydraulic output circuit of the Master Cylinder – the one toward the front of the vehicle. It was connected through a manifold that was added to the circuit to facilitate bleeding air out of the hydraulic circuit.

The Vacuum Booster Pressure sensor was connected to the Brake Booster between the vacuum check valve and the boost input. This was done to ensure that the booster vacuum pressure was being measured and not the intake manifold pressure.

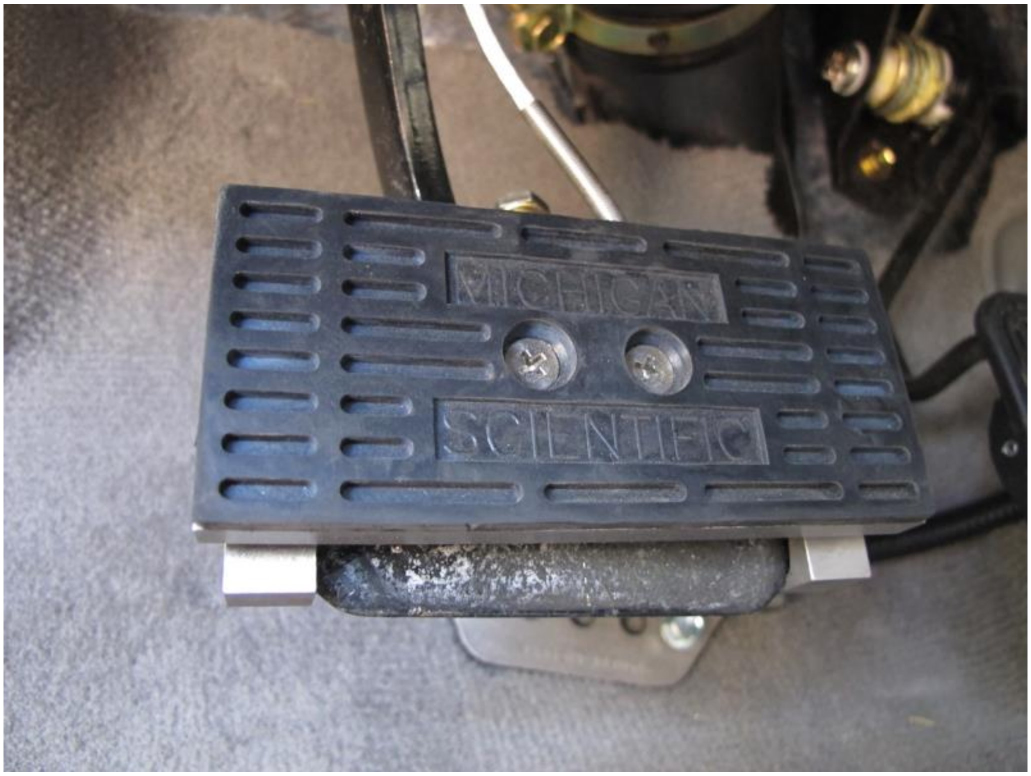


Figure 6 – Brake Pedal Force Transducer

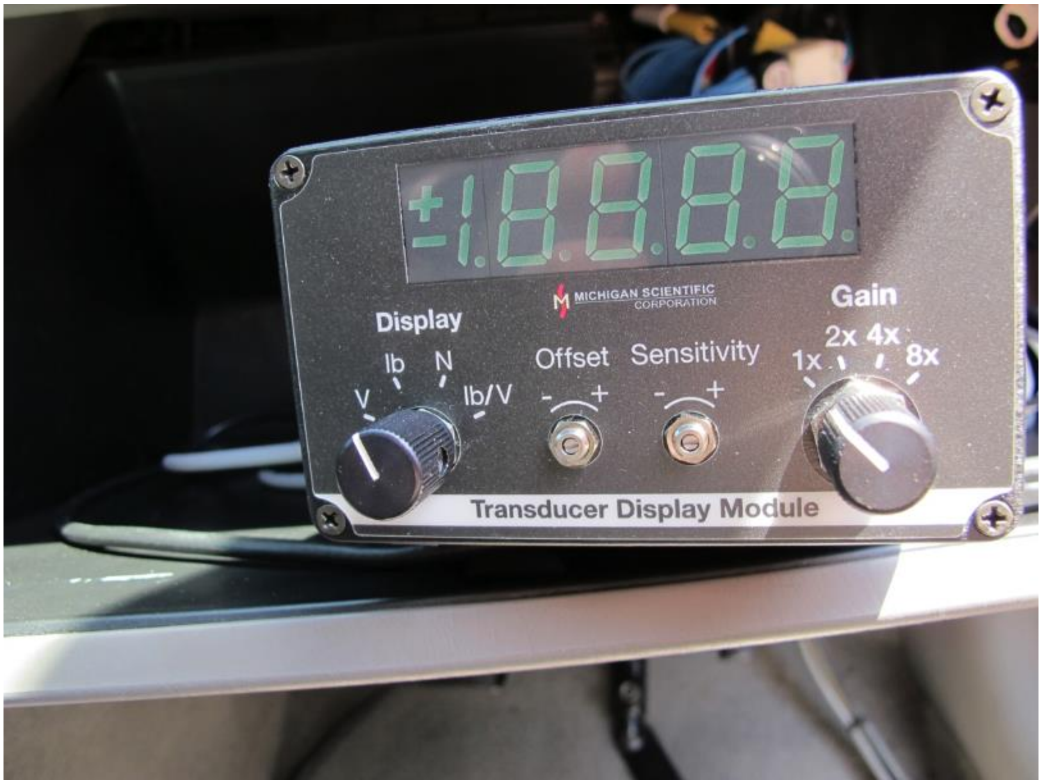


Figure 7 – Brake Pedal Force Transducer Amplifier (Transducer Display Module)

During the setup, the Brake Pedal Force transducer and the Transducer Display Module were adjusted according to the specifications in the Transducer Display Module Operator's Manual to ensure that the measurement output was converted from Volts to lbs of force by the data acquisition system.

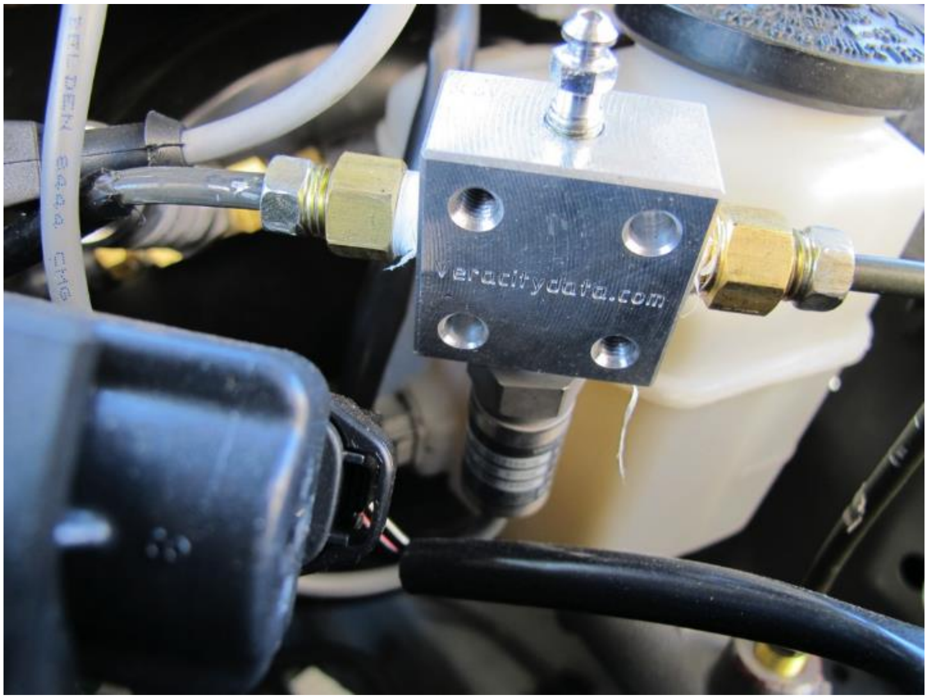


Figure 8 – Brake Master Cylinder Pressure Transducer FRONT view

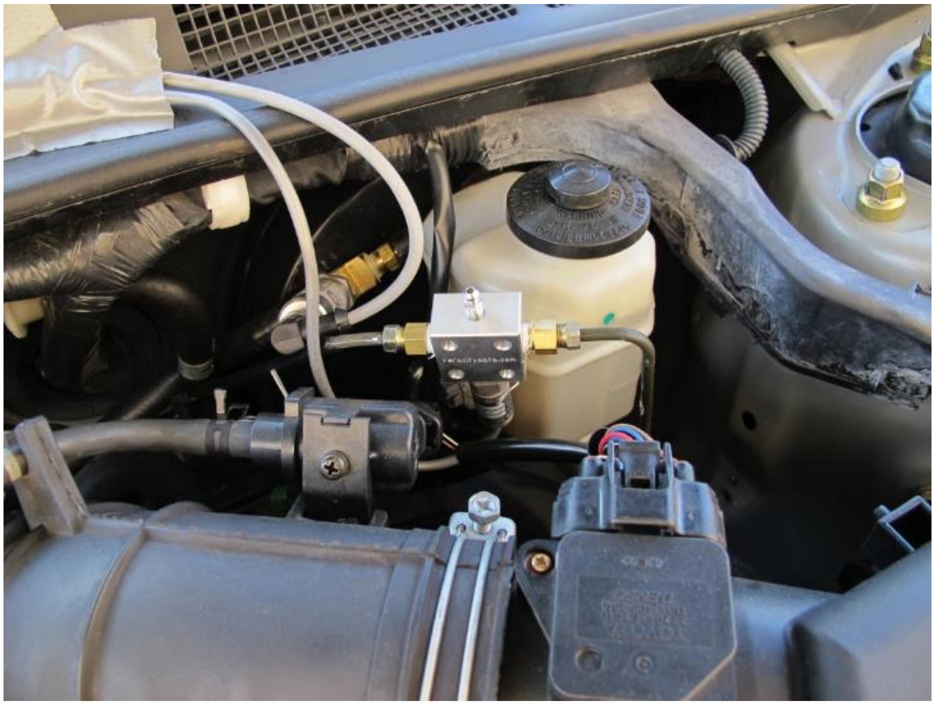


Figure 9 – Brake Master Cylinder Pressure Transducer TOP View

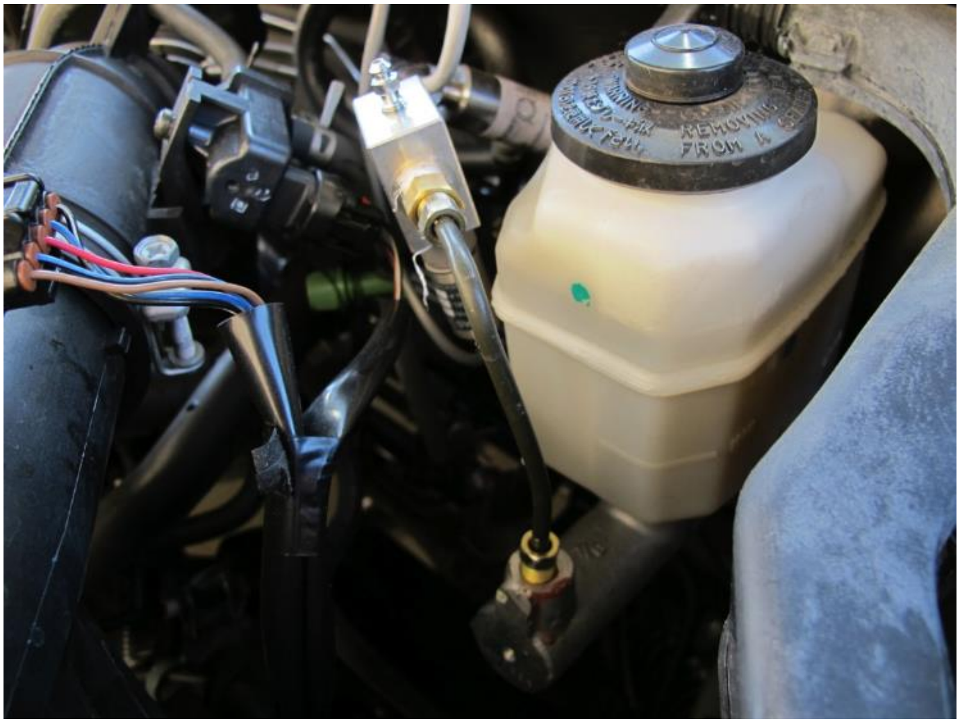


Figure 10 – Brake Master Cylinder Pressure Transducer SIDE view

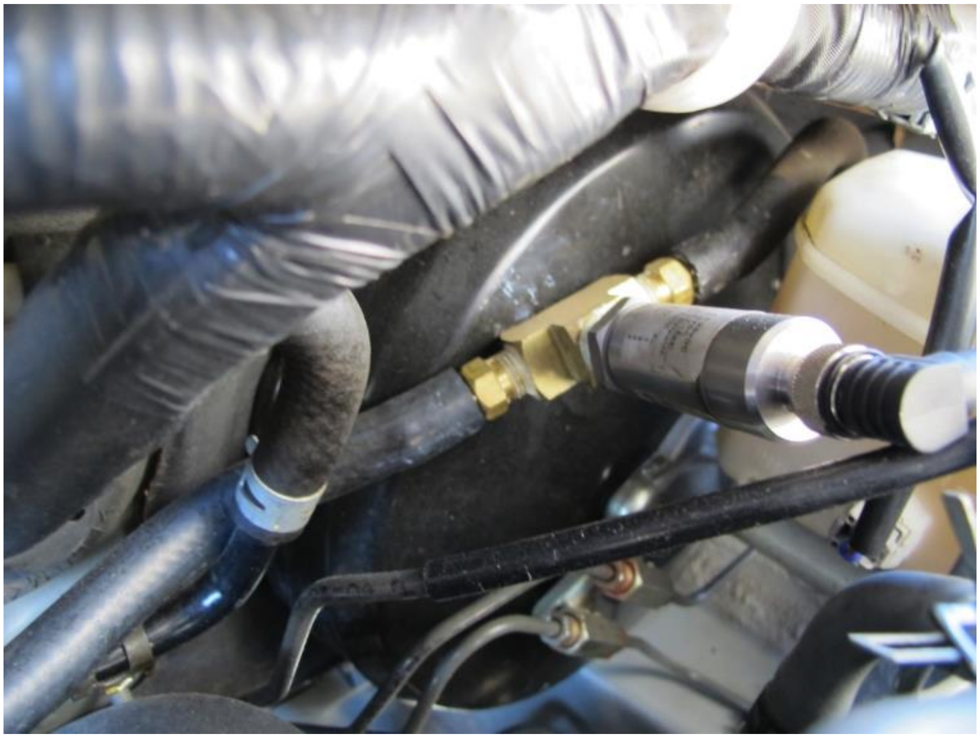


Figure 11 – Vacuum Booster Pressure Transducer

3.3 Passenger Brake Redundant Brake

In order to ensure that the vehicle will be safely stopped, a redundant passenger brake pedal was installed. This is the same type of brake pedal that is installed in driver's education vehicles. It uses a cable to connect this pedal to the pad of the primary brake pedal and allows the passenger, in this case the test facilitator, to brake the vehicle in the event that the driver fails to do so.

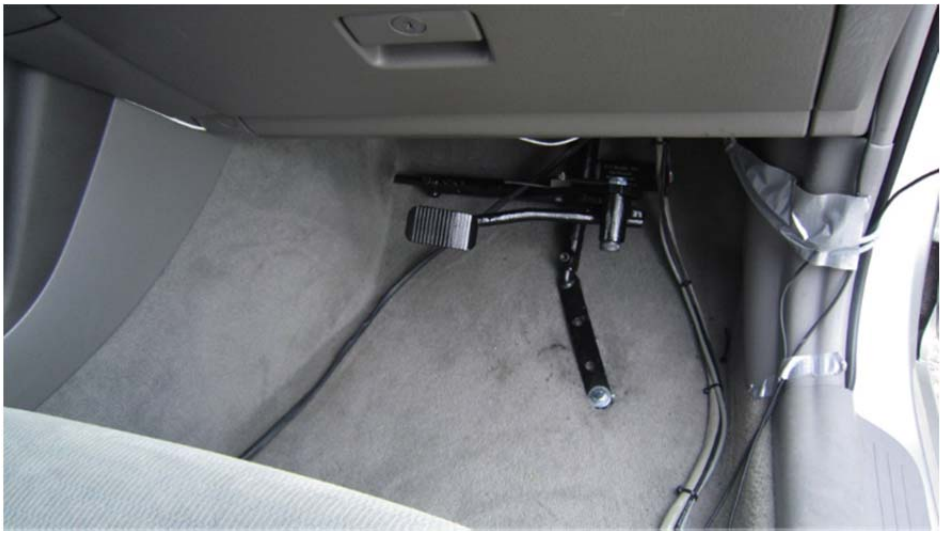


Figure 12 – Passenger Redundant Brake Pedal

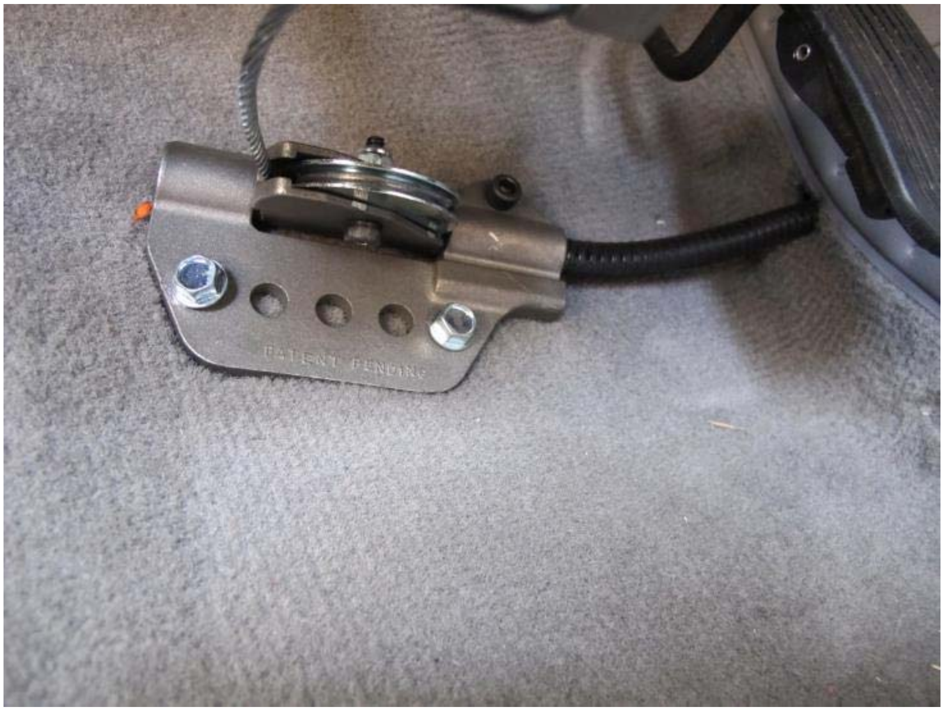


Figure 13 – Driver side cable pulley to operate redundant brake

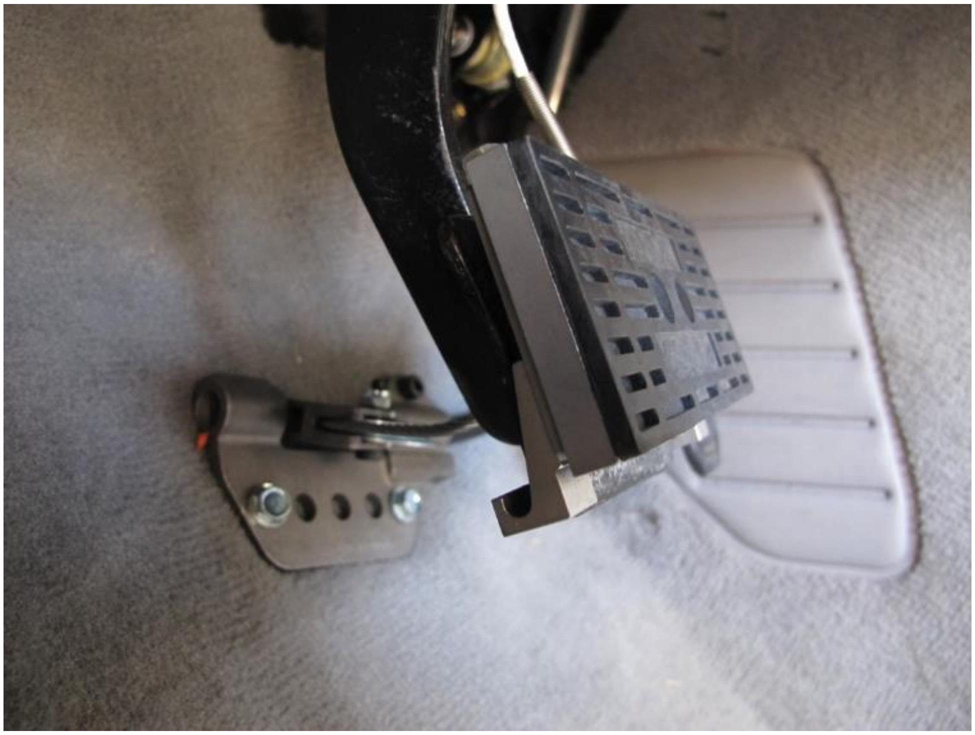


Figure 14 – Redundant brake pedal cable

4 Pre-test Vehicle Checkout

Prior to the start of the tests, a mechanic inspected the vehicle. The brake pads were found to be in new condition, with 90% of their life remaining. The tires were examined and found to have 50% of their tread life remaining.

5 Daily Vehicle Checkout

Prior to the start of each day's testing, a vehicle safety inspection was conducted. This included checking tire pressures, checking the condition of the brake pads and rotors, and driving the vehicle.

Also, during the course of the testing, an infrared temperature sensor was employed to ensure that the brakes were not accumulating excessive heat as each new driver started their test. Rotor temperatures were checked to be below 300 deg F.

6 Data Collected

Attached to this document are all of the data files that were collected during the three-day test.